MMD-1

MINI-MICRO DESIGNER

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TABLE OF CONTENTS

I. General Description . . . . . Page 2

II. Specifications . . . . . Page 3

III. Assembly Instructions . . . . . Page 5

IV. Replacement Parts List . . . . . Page 6

V. Power Supply Assembly and Checkout . . . Page 10

VI. Main Board Assembly and Checkout . . . . Page 18

VII. Principles of Operation . . . . . Page 28

VIII. MMD-1/Kex Program Listing . . . . . Page 37

IX. MMD-1/L/D Program Listing . . . . . Page 41

X. Appendix - Tables . . . . . Page 45

XI. Warranty . . . . . Page 47

XII. Repair & Shipping Information . . . . . Page 48

ILLUSTRATIONS

1. Housing Assembly . . . . . Page 12

1A. Primary Wiring . . . . . Page 14

2. Power Supply . . . . . Page 15

3. Main Board Assembly . . . . . Page 19

4. Schematic Diagram, Sheet 1 . . . . . Page 26

5. Schematic Diagram, Sheet 2 . . . . . Page 27

I. GENERAL DESCRIPTION

The Mini-Micro Designer® (MMD-1) is a complete educational and engineering microcomputer using an 8080-type microprocessor chip. The system has been designed to teach you about microprocessors whether you are a high school student or a digital design engineer. The MMD-1 features direct keyboard entry of data and instructions, status and data indication via LEDs, immediate access to buffered input/output busses and a convenient breadboarding socket. A portion of this socket is hardwired to the input/output bus lines and other critical control lines. This permits you to monitor what is going on, control input/output and interface to other instruments. The socket has been designed to directly accept IC's or functional plug-in modules available from E & L Instruments ("Design Modules"), to enhance your learning and to minimize your breadboarding time. In addition, the same input/output bus and control signals are available on a flex cable connector to more fully utilize the total system capability by adding supplemental hardware. The unit is also equipped with an internal power supply.

The MMD-1 is available in two formats:

- MMD-1/A: Factory assembled, inspected and ready to use. Comes complete with operating manual, Bugbooks V and VI (Self-Taught Microprocessor Course).

- MMD-1/K: Kit form of the MMD-1/A, which requires you to assemble and solder the components into a working unit. Due to installation difficulty, the BP-25 Breadboarding Pins and the SK-10 Interface Socket are factory assembled. The unit comes complete with the operating manual and Bugbooks V and VI (Self-Taught Microprocessor Course).

Both formats are completely described in this manual.

There are many time-saving accessories available to the MMD-1 user. Complete descriptions of available options can be found in the E & L Instruments catalogue, "Teachings of the Modern Masters".

II. SPECIFICATIONS

Central Processor: Intel 8080A or equivalent

Memory: RAM - 512 words (8 bits) on board.

PROM - 256 words (8 bits) comes programmed to accommodate keyboard entry of data. Known as KEX (Keyboard Executive) and is located in prom position Ø.

256 words (8 bits) comes programmed to read data from the cassette and store it in successive memory locations on the M/I (Memory Interface) Board, starting at Ø3Ø - ØØØ. As the data is input it is displayed on the MMD-1's LED's; known as L/D (Loader/Dump) and is located in prom position 1.

Expansion capability: Up to a total of 65,536 words via cable connector - *would require additional power over 2 K RAM.

Displays: PORTS - Three groups of eight (8) LED's individually latched and addressable under software control. Note: during keyboard program entry, these LED's display Lo address, Hi address, and Memory data via the KEX PROM. Latch enables, for each port, via BP-25's, are available for external use.

HALT INDICATOR - LED, located to the left of SK-10, glows when the 8080A has executed a HALT instruction. The HALT status is cleared only through a RESET or a hardware interrupt.

Data Entry: 16 switch keyboard - numerals 0 thru 7, Hi address (H) Lo address (L) go (G) reset (RESET) examine/deposit (S) three optional keys (A, B, C).

Breadboarding Socket: SK-10/IF18 Open area on socket will take up to five (5), sixteen (16) pin ICs and discrete components (from 20 to 26 gauge diameter leads)

Bus signals hardwired to socket:

A0 thru A7	$\overline{\text{OUT}}$
GND	WAIT
+5 volts	READY
INT	D0 thru D7
$\overline{\text{INTE}}$	RESET
$\overline{\text{I ACK}}$	M1
$\overline{\text{MEM R}}$	HALT
$\overline{\text{MEM W}}$	HLDA
$\overline{\text{IN}}$	

II. SPECIFICATIONS

Ribbon Cable Connector: Dual 20 pin, hardwired to same signals as breadboarding socket plus A8 thru A15.

Internal Power Supply: 115 or 230 VAC operation
*Use 1/2 amp fuse at 115 VAC
*Use 1/4 amp fuse at 230 VAC

D.C. Output at 105/210 VAC:	+5 V	±5%	at	1.5 amp
	+12 V	±5%	at	0.5 amp
	-12 V	±5%	at	0.5 amp
Current available for External use:	+5 V		at	0.5 amp
	+12 V		at	0.4 amp
	-12 V		at	0.4 amp

Operation Range: 105 to 125/210 to 250 VAC

NOTE: Unit can be switched from 115V to 230V by setting the switch (LS1) in back of unit with a screwdriver. The 115V plug will have to be replaced with a plug compatible with the receptacle in use.

III. ASSEMBLY INSTRUCTIONS, GENERAL

A. The material has been prepacked in plastic bags in general categories for ease of assembly. Check the contents of the bags to make certain all the correct parts are there. Inspect packing material for any loose parts before discarding.

Bring all shortages or discrepancies to the immediate attention of E & L Instruments.

1. When a wire is brought to a location, the designation "connect" is used; when it is followed by an (S), this indicates it is immediately soldered in place; if no (S) appears, do not solder at this time - other wires will be brought to that point and if solder is applied too early, the assembly will be much more difficult.

2. When soldering diodes and transistors, it is most important that the heat used is minimal - a 35W soldering iron is quite adequate for all of the assembly and a larger wattage iron should not be used.

3. The instructions are given line by line with two "Check-Off" columns. The first is for checking off as you actually do that step; the second is for rechecking if a problem is encountered.

4. Use rosin core solder only. The use of corrosive (acid core) solder or paste fluxes voids any and all warranties on the unit.

5. This manual uses the new IEEE (Institute of Electrical and Electronic Engineers) international standard term "hertz" as the basic unit of frequency. The terms are used as follows:

Hz (hertz)	=	cps	(cycles per second)
KHz (kilohertz)	=	kc	(kilocycles per second)
MHz (megahertz)	=	mc	(megacycles per second)

IV. REPLACEMENT PARTS LIST

PACKING BAG	MANUAL DESIG.	DESCRIPTION	QTY.	P/N	CHECK
POWER SUPPLY PACKAGE	-	Power Supply P.C. Board, Mach.	1	711-0125	
	Q1	Transistor, TIP3055	1	500-0026	
	VR1, VR2	Voltage Reg., 7812UC (LM340-12T)	2	504-0009	
	D1	Bridge Rect., (6 amp-200V) Power Components Inc. BR-62	1	502-0007	
	D2, D3	Bridge Rect., (1 amp-100V) Electronic Devices Inc. PF-05	2	502-0002	
	C1	Elec. Cap. 2200 mfd - 16V	1	523-0044	
	C2, C3	Elec. Cap. 1000 mfd-35V	2	523-0041	
	C4, C5	Tant. Cap. 1.0 mfd-35V	2	524-0009	
	C6	Cer. Cap. 0.1 mfd-50V	1	520-0016	
	R1	Trimpot 2.5Ω Thumbwheel	1	515-0023	
	R2	CCRES 1/4W - 1KΩ - 5%	1	511-0039	
	R3	CCRES 1/4W - 2.2KΩ - 5%	1	511-0046	
	R4	WWRES 2W - .25Ω - 3%	1	519-0023	
	F1	Fuseholder, Littlefuse #348-657	1	563-0019	
	S1	Switch, SPST, w/integral light, Carling Co. LTA-110-PBWR	1	570-0019	
	- *	Fuse, 1/2 amp. Bussman AGC-Slo-Blo	1	563-0013	
	-	Rubber Feet, self-stick, 3M Co. S15112	4	611-0001	
	VR1, VR2	Sil-Pad for Regulator	2	616-0012	
	LS1	AC line voltage select switch	1	579-0003	
	Q1	Sil-Pad for transistor	1	616-0013	
	VR1,VR2, Q1	Nylon Bushing	3	617-0010	

MAIN BOARD PACKAGE	R35,R42	CCRES 1/4W - 10KΩ - 5%	8	511-0062	
	C1	Elec. Cap. 33 mfd - 6.3V	1	523-0019	
	C2	Tant. Cap. 5 mfd - 15V	1	524-0032	
	C3,C5-C15	Cer. Cap. .01 mfd - 50V	12	520-0008	
	C4	Elec. Cap. 3.3 mfd - 50V	1	523-0003	
	C16,C17	Mica Cap. 47 pfd - 5%	2	521-0003	
	R1, R2 R4-R6	CCRES 1/4W - 1KΩ - 5%	5	511-0039	
	R3	CCRES 1/4W - 2.2KΩ - 5%	1	511-0046	
	R7-R30	CCRES 1/4W - 470Ω - 5%	24	511-0031	
	R31-R33	CCRES 1/4W - 4.7KΩ - 5%	3	511-0054	
	R34	CCRES 1/4W - 220Ω - 5%	1	511-0022	
	D1-D24	Red LED,Hewlett Packard 5082-4484	24	551-0005	
	D25	Zener Diode, 5.1V - 5%, IN751A	1	551-0003	
	D26	Zener Diode, 3.3V - 5%, IN746	1	501-0002	
	D27	Red LED,Hewlett Packard 5082-4850	1	551-0003	
	XTAL	Crystal, 5.76 MHz - 0 to 50 degree Cent. series resonance 0.1% Bliley Elec. HC18/U	1	509-0006	

IV. REPLACEMENT PARTS LIST (contd.)

PACKING BAG	MANUAL DESIG.	DESCRIPTION	QTY	P/N	CHECK
MAIN BOARD PACKAGE	-	Binding Post, Red, E.F. Johnson 111-0102-001	1	543-0007	
	-	Binding Post, Black,E.F. Johnson 111-0103-001	1	543-0008	
	-	Binding Post, Blue, E.F. Johnson 111-0110-001	1	543-0009	
	-	Binding Post, White, E.F. Johnson 111-0101-001	1	543-0011	
	-	Capacitor Mount, white nylon	13	616-0006	
	-	Keyboard	1	575-0002	
	-	Connector, Rt. Angle, 40 Pin P.C. mount	1	540-0010	
	-				
	-	Label - Interface Socket	1	633-0038	
INTEGRATED CIRCUITS	A1, A22, A23	SN7404	3	503-0041	
	A2, A3, A30	SN7400	3	503-0014	
	A4	SN74LS174	1	503-0123	
	A5	Intel 8224	1	503-0116	
	A6, A7	Intel 8216	2	503-0117	
	A8	Intel 8080A Microprocessor	1	503-0078	
	A9-A12	Intel 8111-2**	4	503-0118	
	A13, A17	SN74LS05	2	503-0122	
	A14	SN74LS155	1	503-0121	
	A15	Intel 1702-A (Pre-Programmed) (Kex)	1	660-0008	
	A16	Intel 1702-A (Pre-Programmed) (L/D)	1	660-0024	
	A18	SN74L42	1	503-0081	
	A19	SN7402	1	503-0042	
	A20, A21	SN74L04	2	503-0120	
	A24-A29	SN74LS75	6	503-0187	
	A31	SN74365	1	503-0086	
	A32, A33	SN74148	2	503-0119	
	U1	Voltage Reg., LM723 (DIP) +5 volt (Power Supply)	1	504-0014	
SOCKET	J1-J3 J13, J17 J19-J23 J30, J34	Socket, DIP, 14 Pin	12	542-0005	
	J4-J7 J14, J18 J24-J29 J31-J33	Socket, DIP, 16 Pin	15	542-0008	
	J9-J12	Socket, DIP, 18 Pin	4	542-0021	
	J15, J16	Socket, DIP, 24 Pin	2	542-0017	
	J8	Socket, DIP, 40 Pin	1	542-0016	

IV. REPLACEMENT PARTS LIST (contd.)

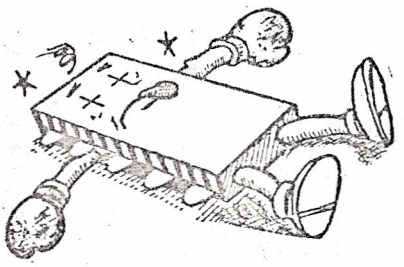
PACKING BAG	MANUAL DESIG.	DESCRIPTION	QTY	P/N	CHECK
HARDWARE	-	6-32 x 1/2" Pan Hd. Screw	8	605-0002	
	-	6-32 Hex Nut	4	606-0012	
	-	#6 Lockwasher	2	607-0008	
	-	#6 Ground Lug	1	545-0020	
	-	4-40 M/F Standoff	3	615-0019	
	-	4-40 x 1/4" Pan Hd. Screw	3	605-0025	
	-	4-40 Hex Nut	6	606-0006	
	-	#4 Lockwasher	8	607-0001	
	-	#4-40 x 3/8" Pan Hd. Screw	5	605-0037	
		#4-40 NUT, Small	2	606-0009	
WIRE (581-0005)	-	1-1/2" (3,81 cm) 18 ga. White	1		
	-	1-1/2" (3,81 cm) 18 ga., Black	1		
	-	2" (5, 1 cm) 18 ga., Black	1		
	-	5-1/2" (13,97 cm) 18 ga. White	1		
	-	5-1/2" (13, 97 cm) 18 ga. Black	1		
	-	6" (15, 24 cm) 18 ga. White	1		
	-	6" (15,24 cm) 18 ga. Black	1		
	-	6-1/2" (16,51 cm) 18 ga. White	1		
	-	3 1/2" (8,9cm) 22 ga., Green	9		
	-	5" (12,7cm) 22 ga., Orange	6		
	-	12" (30,5cm) 22 ga., White	1		
	-	12" (30,5cm) 22 ga., Red	1		
	-	12" (30,5cm) 22 ga., Blue	1		
	-	12" (30,5cm) 22 ga., Black	1		
		12" (30,5cm) 22 ga. Buss Wire	1		
FACTORY INSTALLED MAIN BOARD ASSEMBLY	-	P.C. Board, Machined	1	711-0099	
	BP	BP-25 Breadboarding Pin	36	544-0004	
	SK-10	SK-10/IF-18 Interface Socket	1	415-0003	
	-	4-40 x 5/8" Flat Hd. Screw	6	605-0033	
	-	#4 Lockwasher	6	607-0001	
	-	4-40 Hex Nut	6	606-0006	
	-	6-32 x 1/2" Pan Hd. Screw, used to mount Main Board to Housing installed for shipping	4	605-0002	
MISCELLANEOUS	-	Housing (E&L Instr.)	1	620-1011	
	T1	Transformer, (E&L Instr.)	1	531-0017	
	-	Line Cord w/Molded Plug (115V)	1	567-0002	
	-	Strain Relief, Heyco Inc. SR6P4	1	617-0002	
	-	Operating Manual	1	801-0082	
	-	Bugbook V	1	802-0023	
	-	Bugbook VI	1	802-0024	
	-	8080A Inst. Reference Card	1	803-0147	
	-	Yellow Warranty Card	1	801-0137	

* *For 230V operation use:*

	-	*1/4 amp Fuse-Bussman-AGC Slo-Blo*	*1*	*563-0020*	

** Faster RAMs (8111A-4) (2111-2) may be substituted.

CAUTION!



STATIC ELECTRICITY

KILLS

the following devices:

INTEL 8080 Microproccessor chip

INTEL 1702A-2 PROM

INTEL 8212 IN/OUT Port chip

INTEL 8102A-2 RAM

INTEL 8111-2 RAM

INTEL 8216

INTEL 2102A-6 RAM

Although protection against electrostatic effects is provided by built-in circuitry, the following handling precautions should be taken:

1. Soldering iron tips and test equipment should be grounded.
2. Devices should not be inserted in non-conductive containers such as conventional plastic snow or trays.
3. Assembly work surfaces should be grounded.
4. Avoid carpeting or other furnishings that encourage electrostatic charging of assembly personnel.

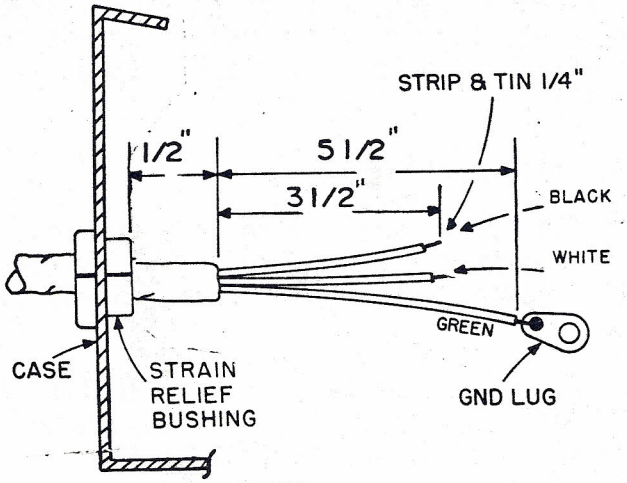
V. POWER SUPPLY ASSEMBLY AND CHECKOUT
(See Illustrations 1, 1A and 2)

A. Line Cord Preparation

CONST. CHECK

If your unit is for 230V operation, the line cord will have no plug attached. A plug must be obtained that is suitable for the receptable available.

1. Prepare Line Cord as shown below. Slide strain relief onto Line Cord with large end towards plug end of cord. _____ _____



POWER CORD PREPARATION

2. Insert Line Cord through hole in rear of housing. Compress Strain Relief and snap into hole. Connect the Ground Lug to the Green wire as shown. _____ _____

B. Transformer Installation (See Illustration 1)

1. Scrape paint from around frontmost transformer mounting hole to bare metal for good grounding contact. _____ _____

2. Fasten Transformer into the housing with (2) 6-32 x 1/2" Pan Head Screws, #6 Lockwashers and 6-32 Hex Nuts. Place Ground Lug under Transformer at frontmost hole when fastening. Terminals 1 through 4 with wires attached should be closest to the Line Cord (See Illustration 1). _____ _____

C. Mounting Voltage Regulators VR1, VR2 and Power Transistor Q1

1. Install with Sil-Pads shown in Illustration 1 using a 4-40x3/8" Pan Hd. Screw and 4-40 Hex Nut. _____ _____

2. Repeat the above step for VR1 and Q1. _____ _____

D. Completion of Case Assembly

1. Install (3) standoffs in the 3 remaining holes in the bottom of the housing using the 4-40 x 1/4" Pan Head Screws and

	CONST.	CHECK

#4 lockwashers.

2. Install line switch LS1 with (2) 4-40 x 3/8" screws, (2) 4-40 hex nuts (small), and (2) #4 washers. Make sure 230V shows toward the top of case. (See Illus. #1). _____ _____

3. Install Fuseholder (F1) into hole next to switch on housing with word "TOP" printed on Fuseholder in the UP position. Push until is snaps into place. _____ _____

4. Install On/Off power switch (S1) in hole at extreme left on rear of housing with terminal 3 towards the top. Push in until it snaps into place. (See Illustration #1) _____ _____

STEPS 5 Through 10 See Illustration #1A

5. Connect 5-1/2" (13,97 cm) white wire from terminal 4 of T1 and white wire from Line Cord to top lug on switch (S1-3). Connect 1-1/2" (3,81 cm) white wire from (LS1-5) to (S1-3) (S). _____ _____

6. Connect 6-1/2" (16,51 cm) white wire from (LS1-4) (S) to terminal 2 of T1. Connect 6" (15,24 cm) white wire from terminal 2 of T1 (S) to (LS1-3) (S).

7. Connect 5-1/2" (13, 97 cm) black wire from terminal 1 of T1 (S) to lower lug on Switch (S1-1). Connect 1-1/2" (3,81 cm) black wire from (S1-1) (S) to (LS1-1) (S). _____ _____

8. Connect 2" (5,1 cm) black wire from middle lug on Switch (S1-2) to the top lug on fuseholder (F1) (S). _____ _____

9. Connect 6" (15,24 cm) black wire from (LS1-2) to terminal 3 of T1 (S). _____ _____

10. Connect black wire from Line Cord to lower lug on fuseholder (F1) (S). _____ _____

PUT HOUSING ASIDE AT THIS POINT.

E. Power Supply P.C. Board Assembly (See Illustration 2)

NOTE: All solder connections are made on lower side of board.

1. The (2) jumper wires using the 22 ga. bus wire supplied. Note the jumpers should be flat against the board before soldering. _____ _____

2. The 14-Pin IC Socket (J34). Note the notch on socket is adjacent to white doe on P.C. Board. _____ _____

3. The 2.5K Trimpot (R1). _____ _____

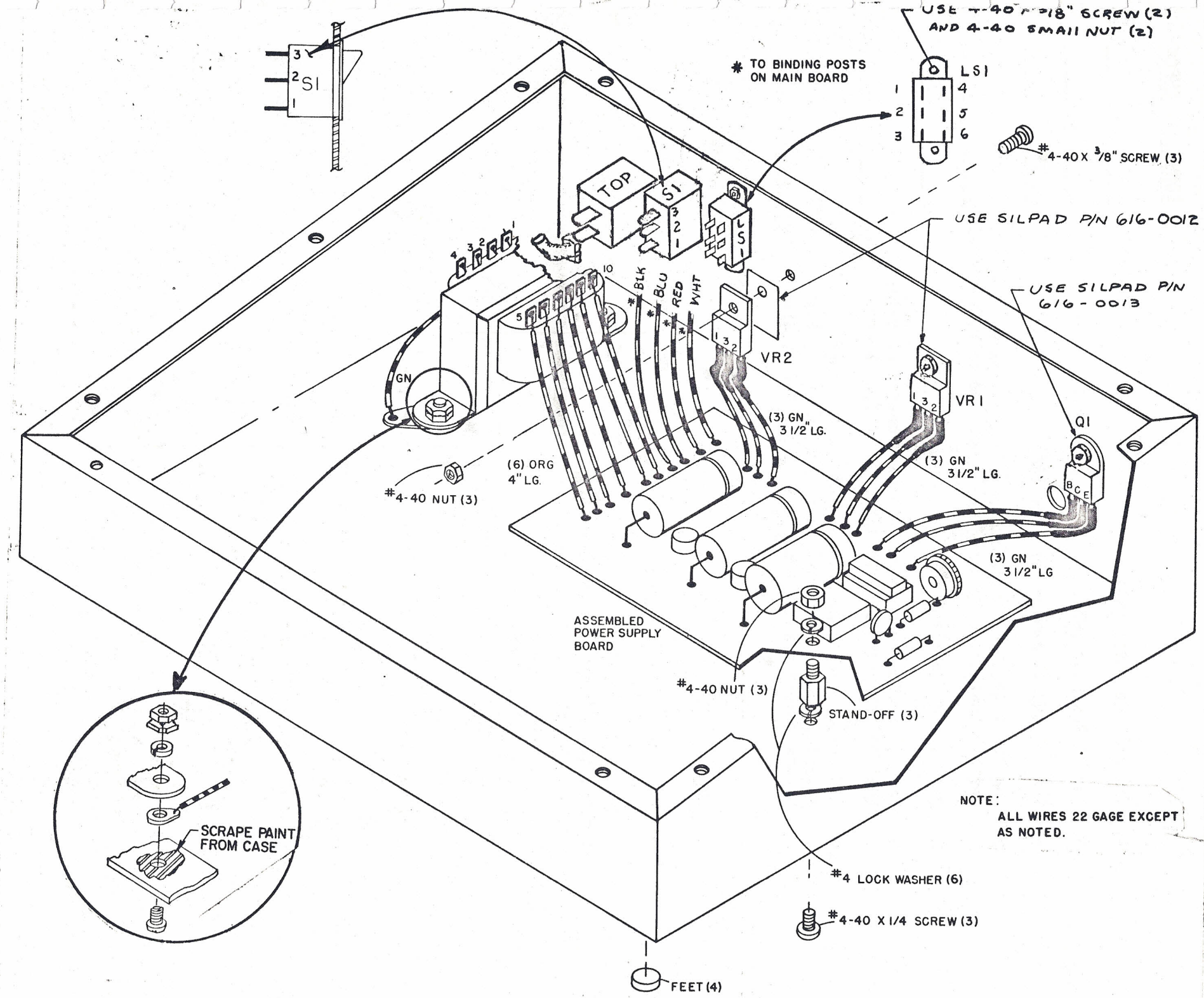
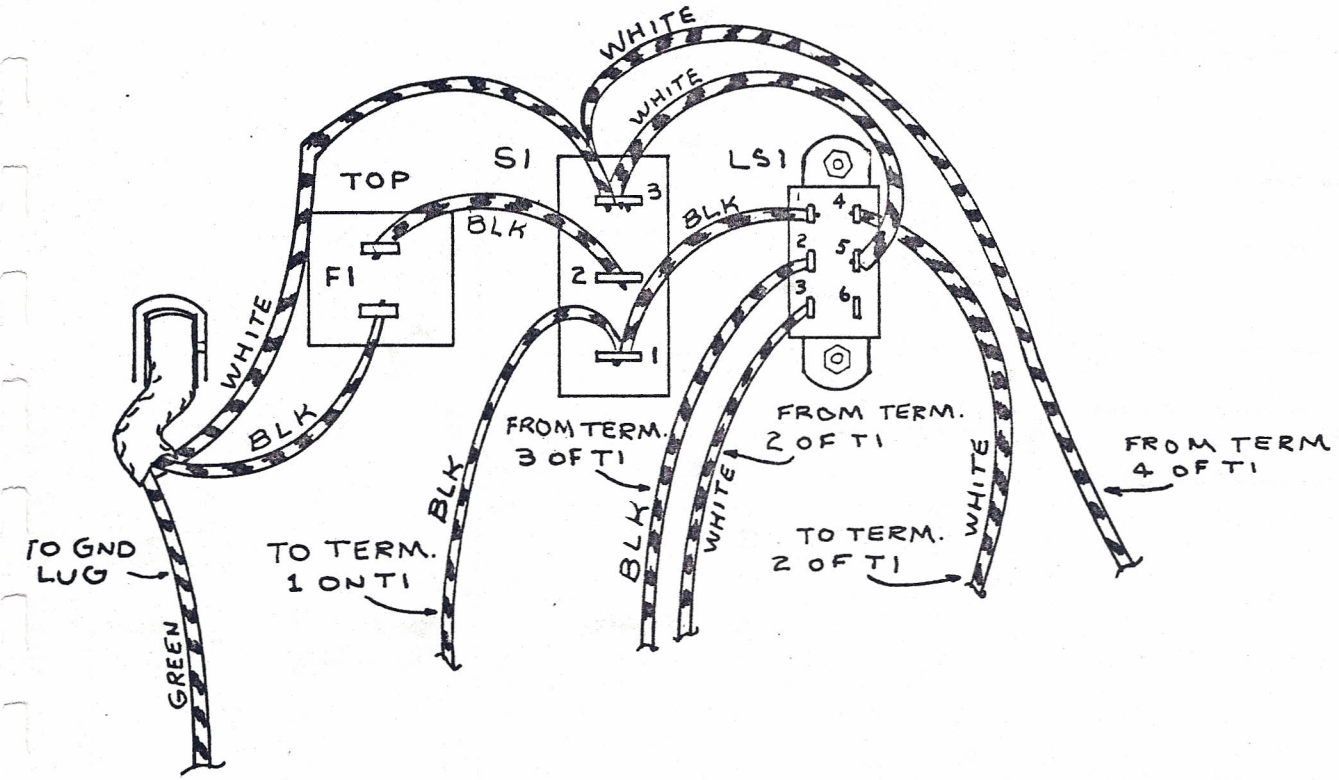


ILLUSTRATION #1

		CONST.	CHECK
4.	The 2.2K Resistor (R3).	_____	_____
5.	The 1K Resistor (R2).	_____	_____
6.	The .25 ohm wirewound resistor (R4).	_____	_____
7.	The (2) 1 mfd tant. capacitors (C4, C5), making certain that polarity agrees with marking on P.C. Board.	_____	_____
8.	The .1 mfd capacitor (C6).	_____	_____
9.	The (2) bridge receifiers (D2, D3), making certain that polarity agrees with markings on P.C. Board.	_____	_____
10.	The bridge receifier (D1) making certain that polarity agrees with marking on P.C. Board. This Device should stand approx. 3/8" above P.C. Board.	_____	_____

(Instructions continued on Page 16.)



PRIMARY WIRING

ILLUSTRATION 1A

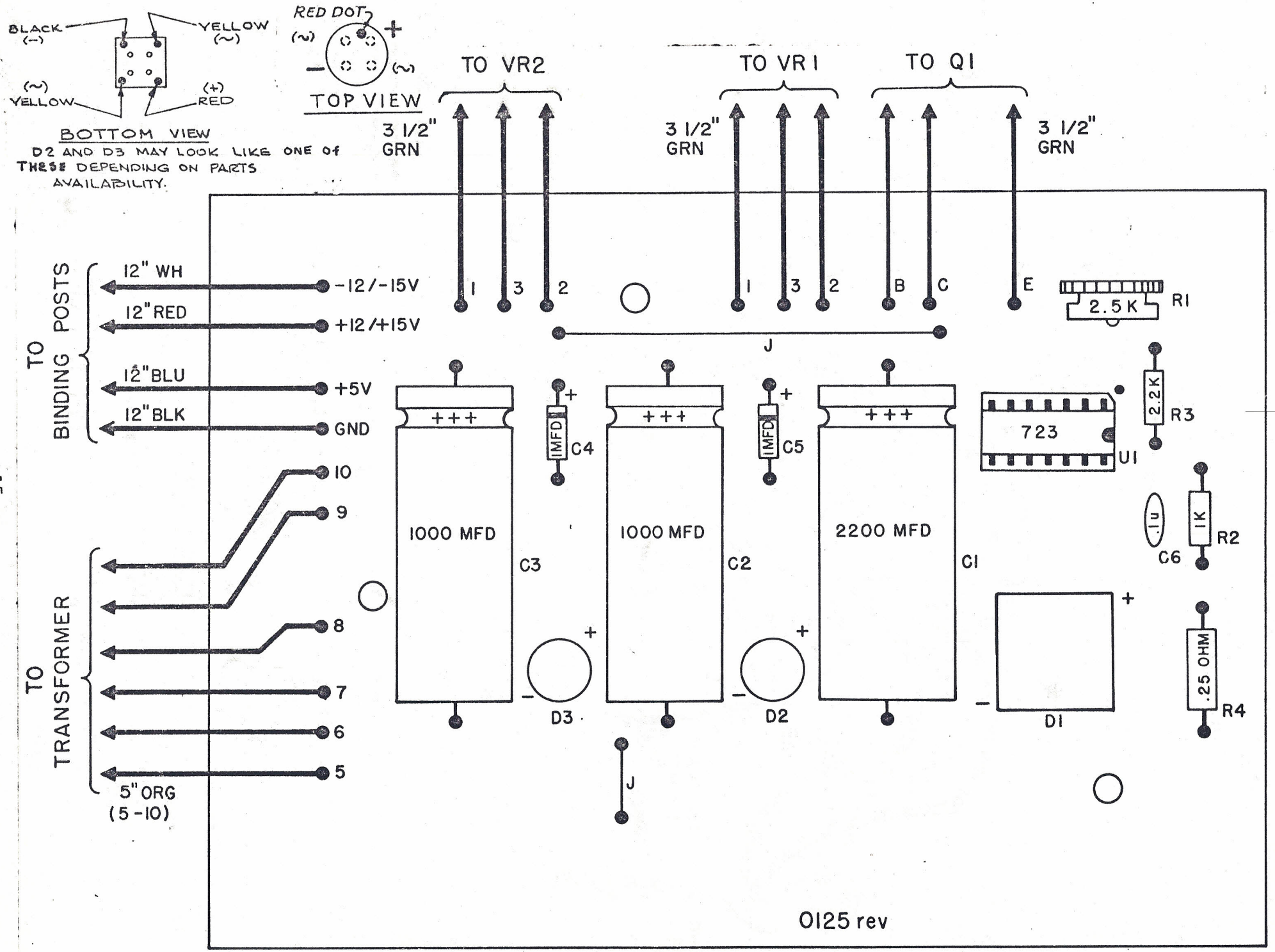


ILLUSTRATION #2

E. Power Supply P.C. Board Assembly (contd.) CONST. CHECK

11. The (2) 1000 mfd capacitors (C2 & C3), and 2200 mfd capacitor (C1) making certain that polarity on capacitors agree with markings on P.C. board. _____ _____

12. The (9) 3 1/2" (8,9cm) long green wires at hole locations marked 1,2,3,B,C, & E along the top edge of the P.C. board. _____ _____

13. The (6) 5" (12,7cm) long orange wires at hole locations marked 5,6,7,8,9, & 10 on the left side of the P.C. board. _____ _____

14. The 12" (30,5cm) long black wire at hole marked "GND" on P.C. board. _____ _____

15. The 12" (30,5cm) long blue wire at hole marked "+5" on P.C. board. _____ _____

16. The 12" (30,5cm) long red wire at hole marked "+12" on P.C. board. _____ _____

17. The 12" (30,5cm) long white wire at hole marked "-12" on P.C. board. _____ _____

DO NOT install the I.C. at this time.

This completesthe Power Supply Board Wiring.
Refer to Illustration 1 for the following steps:

18. Position the Power Supply Board over the Stand-Offs in the Housing and fasten with (3) 4-40 Hex Nuts and #4 Lockwashers. _____ _____

19. Slip a 1" (2,5cm) piece of Heatshrink Tubing over each green wire then solder the (3) sets of 3 green wires to the corresponding semiconductors at the rear inside of the Housing as shown. Slide the Tubing up over the entire lead and heat to secure. _____ _____

20. Solder the (6) orange wires to the terminals on the Transformer (T1): _____ _____
    Hole #5 to term. 5.
    Hole #6 to term. 6.
    Hole #7 to term. 7.
    Hole #8 to term. 8.
    Hole #9 to term. 9.
    Hole #10 to term. 10.

	CONST.	CHECK

The remaining 4 wires, black, blue, red, and white still go to the four Binding Posts on the Main Board at the Final Assembly.

F. Testing the Power Supply

1. Insert I.C. (U1) LM723 into socket. Be certain that pin 1 is located next to the dot on the P.C. board. _____ _____

2. Install the Fuse into the Fuseholder (F1). _____ _____
   1/2 amp for 115V.
   1/4 amp for 230V.

3. Check that the 4 unconnected wires are not touching each other or touching the Housing. _____ _____

4. Plug Line Cord into an Outlet and turn on Switch (S1). Red light on switch should glow. If this does not happen, unplug cord from power and re-check all wiring. _____ _____

5. Connect appropriate lead of D.C. voltmeter to black wire "GND." _____ _____

6. Touch the other lead of voltmeter to blue, red & white wires to read the following voltages: _____ _____
   Blue*.....+5V ±5%
   Red.....+12V ±5%
   White.....-12V ±5%

*Adjust the Thumbwheel on the Trimpot (R1) to obtain this value. If any voltages are missing or incorrect, unplug the power cord and recheck all wiring.

7. Install (4) Rubber Feet at the corners of the bottom of the Housing. _____ _____

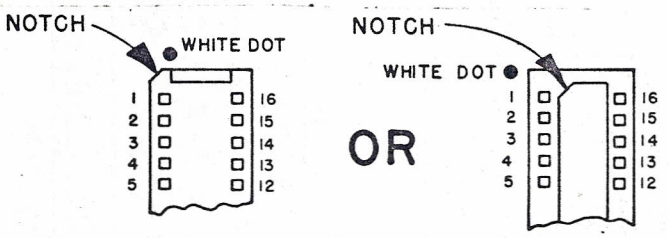
This completes Housing and Power Supply Assembly. Set aside and proceed to the Main Board Assembly.

VI. MAIN BOARD ASSEMBLY AND CHECKOUT (See Illustration 3)

CONST. CHECK

All solder connections are made on bottom (solder side of this board.

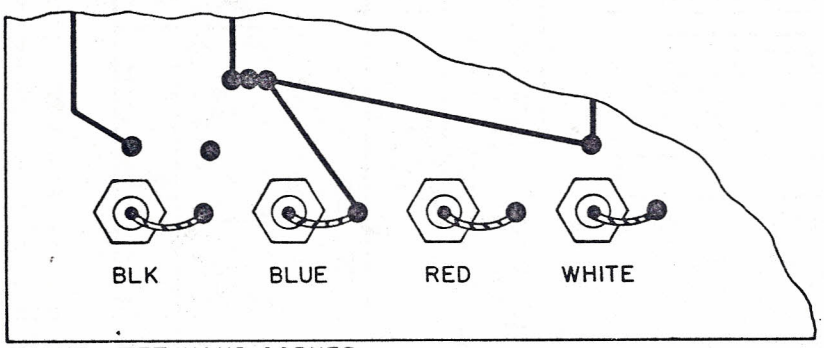
1. Insert and solder all I.C. sockets in their proper locations. Be extremely careful to avoid solder bridges between pins or adjacent clad. Pin 1 of the sockets is indicated by a notch or cut-off corner which is placed nearest to the white dot on the Main Board. Be certain that all leads protrude thru board and socket is flush with top of board before soldering. ____ ____



SOCKET INSTALLATION

2. Insert and solder the 40 pin ribbon connector. The connector supplied may be numbered 1 thru 40 or A thru VV. This is not important, just be sure that the horizontal pins for mating plug are on the right side of the board. ____ ____

3. Attach Binding Posts to Main Board as shown with colors in positions as indicated below. When tightening Binding Posts turn so that test lead holes are parallel with sides of board to allow test lead insertion. ____ ____



UPPER LEFT HAND CORNER
BOTTOM SIDE OF MAIN BOARD

4. Cut (4) 1" (5,1cm) pieces of 22 ga. buss wire; Insert each wire into the corresponding hole as shown and solder. Trim the excess wire from the top of the board. ____ ____

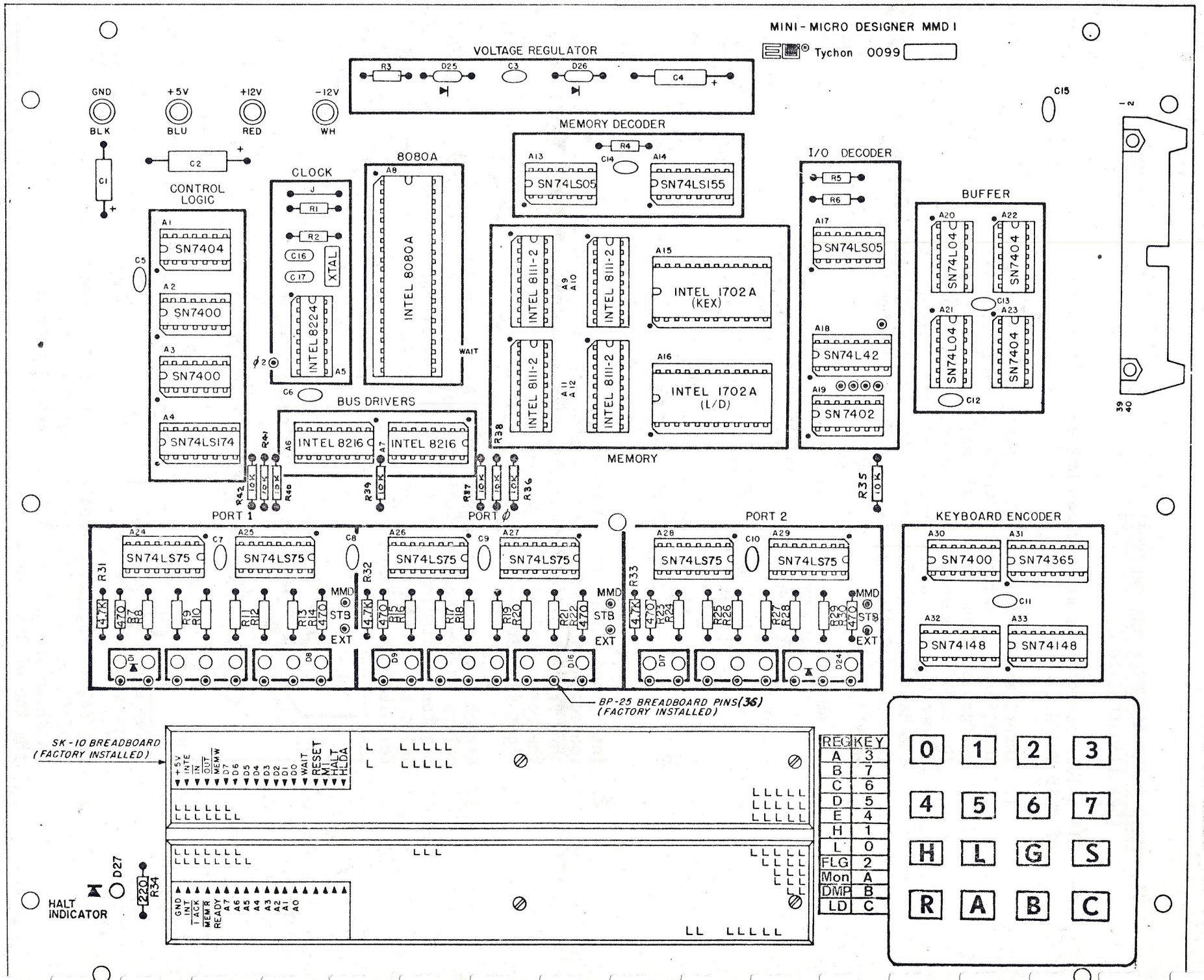
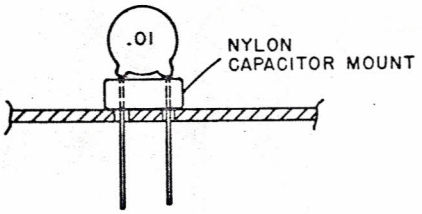


ILLUSTRATION #3

VI. MAIN BOARD ASSEMBLY AND CHECKOUT (contd.) CONST. CHECK

5. Insert nylon capacitor mounts over leads on (12) .01 mfd disc capacitors (C3, C5 thru C15) and insert and solder in the proper locations. ____ ____



6. Insert and solder the 33 mfd electrolytic capacitor (C1) and 5 mfd tant. capacitor (C2) at the top left hand corner of the board with (+) lead at the (+) silkscreened on the P.C. board. ____ ____

The following 4 steps Refer to Voltage Regulator Section

7. Insert and solder the following:
   a. The 2.2K resistor (R3). ____ ____
   b. The 1N751 5.1V Zener diode (D25). Observe Polarity. ____ ____
   c. The 1N746 3.3V Zener diode (D26). Observe Polarity. ____ ____
   d. The 3.3 mfd Electrolytic capacitor (C4). Observe Polarity. ____ ____

The following 4 steps Refer to Clock Section

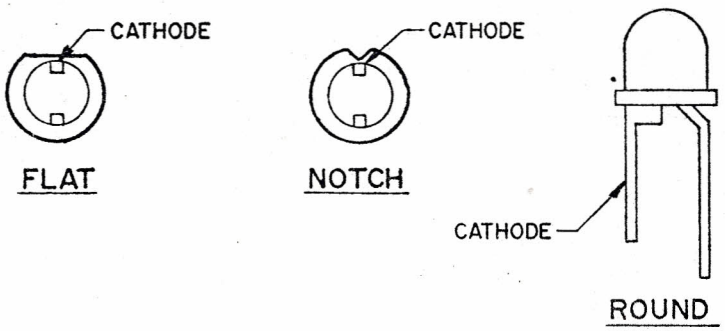
8. Insert and solder the following:
   a. The 22 ga. black wire jumper. ____ ____
   b. The (2) 1K resistors (R1 & R2). ____ ____
   c. The (2) 47 pf Mica capacitors (C16 & C17). ____ ____
   d. The 6.75 MHz crystal, (XTAL), using 1 capacitor mount. ____ ____

9. Insert and solder (1) 1K resistor (R4) in the Memory Decoder Section. ____ ____

10. Insert and solder (2) 1K resistors (R5 & R6) in the I/O Decoder Section. ____ ____

11. Insert and solder (24) 470Ω resistors (R7 thru R30) at the 3 ports, Ø, 1 & 2. ____ ____

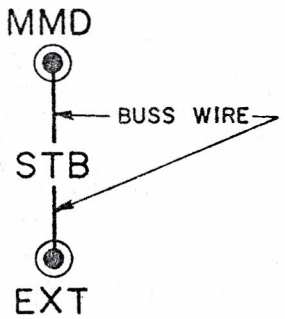
12. Insert and solder (24) Red L.E.D.'s (D1 thru D24). Be sure to note polarity.
    Please be advised of the three types of L.E.D.'s E&L carries, as shown, on next page. One of these types is contained in this kit. ____ ____



CAUTION!!! The (24) L.E.D.'s are easily damaged by excessive heat during soldering. Install the L.E.D.'s such that they stand up 1/8" from the top of the P.C. Board Solder them in from the bottom side of the board, only. Do not solder them in from the top side of the board as this is unnecessary and risks damaging them from excessive heat.

13. Insert and solder the (3) 4.7KΩ resistors (R31 thru R33). ____ ____

14. Insert (3) 3/4" (19,1mm) pieces of buss wire into the (6) BP-25 pins marked "MMD," "STB," "EXT," as shown below. ____ ____



15. Insert and solder the large Red L.E.D. (D27) in the Halt Indicator spot next to the SK-10 socket on the P.C. Board Be sure that this L.E.D. is put in FLUSH with the top of the board and then soldered. Note polarity. ____ ____

16. Insert and solder the 220Ω resistor (R34) in P.C. Board next to large Red L.E.D. labeled Halt Indicator. ____ ____

	CONST.	CHECK
17. Insert and solder (8) 10KΩ Resistors R35 through R42.	_____	_____
18. Insert and solder the keyboard, making sure that the keyboard is mounted FLUSH with the top of the P.C. Board. Solder and clip the leads once it is mounted.	_____	_____
19. Peel Labels from backing for the SK-10 Bread-boarding socket and affix as shown in Illustration 3.	_____	_____
20. Place completed Main Board above the Housing, face down (solder side up), with the Binding Posts at the lower left.	_____	_____
21. Solder the (4) remaining wires, black, blue, red and white from power supply board to corresponding Binding Post terminals on Main Board.	_____	_____
22. Place Main Board on top of Housing Assembly and fasten with (10) 6-32 x 1/2" long screws.	_____	_____

You will now make some initial tests before inserting the integrated Circuit Chips.

VI. MAIN BOARD ASSEMBLY AND CHECKOUT (contd.) CONST. CHECK

A. Main Board Checkout

1. Plug unit into an outlet. Place switch (S1), in the UP position. The red light should come on. _____ _____

2. Connect common lead of D.C. Voltmeter to black binding post (GND). Check voltages at the following points. _____ _____

D.C. Volts	+5V	-5V	+12V	-9V
I.C. Number	Pin Numbers			
A8	20	11	28	--
A5	16	--	9	--
A6, A7	16	--	--	--
A9-A12	18	--	--	--
A15, A16	12,13,15 22,23	--	--	16,24*
A24-A29	5	--	--	--
A1-A3, A13, A17 A20-A23, A30	14	--	--	--
A4,A14,A18-A19, A31-A33	16	--	--	--

*Prom must be in place for -9V to be present.
Remember to reverse D.C. Voltmeter leads for Negative Voltage Checks.

3. Remove power from the MMD-1, and insert the SN74LS75 latches (A24 thru A29). Be sure to note how the I.C.'s go into their sockets. There is a small mark near pin 1 for all the I.C.'s. This is part of the white screening. With the latches installed, apply power to the system. All of the L.E.D.'s should be on. If any are not on, check the associated SN74LS75 latch. With power still applied, ground the data bus lines D0 thru D7 at the SK-10 socket one at a time. One of the L.E.D.'s in each group of eight should go out, one at a time. If this doesn't happen, again check the SN74LS75's. This will prevent accidental short circuits at the I.C.'s which could cause damage. _____ _____

4. The keyboard section consists of 16 keyswitches, 15 of which are used to input data and one of which is hardwired to the 8224 chip for the Reset function. The keyswitch closures are encoded in two SN74148 octal encoder chips and the encoded binary data is gated onto the bus through a three state DM8095 or SN74365 chip. Remove Power from the MMD-1, then insert the four integrated circuits,

VI. MAIN BOARD ASSEMBLY AND CHECKOUT (contd.) CONST. CHECK

A. Main Board Checkout

6. Turn on the power with all the I.C.'s in place and check the power supply voltages at the Binding Posts. They should be at their preset levels of +5 and ±12 volts. If these are correct, your Mini-Micro system should be operational. _____ _____

7. Depress the Reset key, R. The L.E.D. displays should now indicate 003 or 00000011 at the HI and 000 or 00000000 at the LO. The Output Port 2 L.E.D.'s may have some random data present. If this doesn't happen, remove the power and carefully check your system. Things to check for are solder bridges, cold joints, unsoldered I.C. pins and incorrect I.C. orientation. Plated through holes don't have to be soldered unless there is a component or other lead going through them. Also check for +5 volts and ground at all the I.C.'s. Refer to Step 2 of Main Board Checkout. _____ _____

8. If the L.E.D.'s are on in the correct pattern, depress and release the S key. Each time that this key is pressed, the LO address information should be incremented by 1. If this doesn't happen, check the keyboard encoder section and the Input/Output sections of the Mini-Micro. _____ _____

9. If the L.E.D's are operating correctly, try and enter some data, 0 through 7 from the keyboard. The binary codes for these switches should enter the Data Register display (Port 2) in the three least significant bits. You will note that as new data is entered the old data is shifted to the left where it finally disappears as more new data is entered. The actual operation of the KEX software to input and output data is discussed later in the KEX software section. _____ _____

VI. MAIN BOARD ASSEMBLY AND CHECKOUT (contd.) CONST. CHECK

A. Main Board Checkout

A30 thru A33. The keyboard is tested by monitoring the data on the L.E.D.'s. CAREFULLY ground pin 1 on A31 being very sure pin 2 is not also shorted. Also ground the IN line on the SK-10 socket. This will cause data from the keyswitch encoders to constantly be output to the bus. With these two points grounded, apply power and depress the keys, one at a time. The binary data for each keyswitch will be observed on the L.E.D.'s at all of the output ports, simultaneously. You will also note that the most significant bit, D7, will be on whenever one of the keys is depressed. This is often called a 'flag' since it is used to flag down the computer and tell it that one of the switches is ready with data. The second, third, and fourth most significant digit may be on, as they are not directly connected to the keyboard encoder. The lower left key will not output any data since it is hardwired to the 8224 clock chip. You can check this key's operation by testing the voltage at pin 1 of A5, the 8224 clock chip. When A5 is installed, it should normally be at about zero volts and will go to about 3 volts when the reset key is depressed.

5. After I.C. voltages, L.E.D. display and keyboard sections have been tested, install the remaining I.C.'s Remember to be sure that the I.C.'s are properly oriented as shown on the screened legends on the P.C. Board. Be sure that the R/W Section is installed correctly w/all four 18 pin sockets and all four 8111's going in sections 2 and 3, the KEX PROM (1702A) going in position 0, and the L/D PROM (1702A) going in position 1. (Refer to Illustration 3).
If you have not already done so, obtain one of the 1702A PROMs with the Keyboard Executive (KEX) software, and one 1702A PROM with the Load/Dump (L/D) software in it. Preprogrammed PROMs are available (see Parts List) and if you already have a 1702A PROM, it may be programmed from the listing provided. There are currently a number of 1702A type PROMs available. These are 4702A and 8702A. These are pin-for-pin equivalents of the 1702A, but their access times are slower. The 1702A PROMs or equivalents should have a maximum access time of about 1300 nanoseconds to work with the Mini-Micro. If you purchase a 'surplus' PROM, be sure that these conditions are met. The PROM containing the KEX software must be placed in the PROM position 0. It will not work correctly if placed in position 1 since the addresses will be incorrect. The PROM containing L/D software must be placed in the PROM position 1. It will not work correctly if placed in position 0 since the addresses will be incorrect.

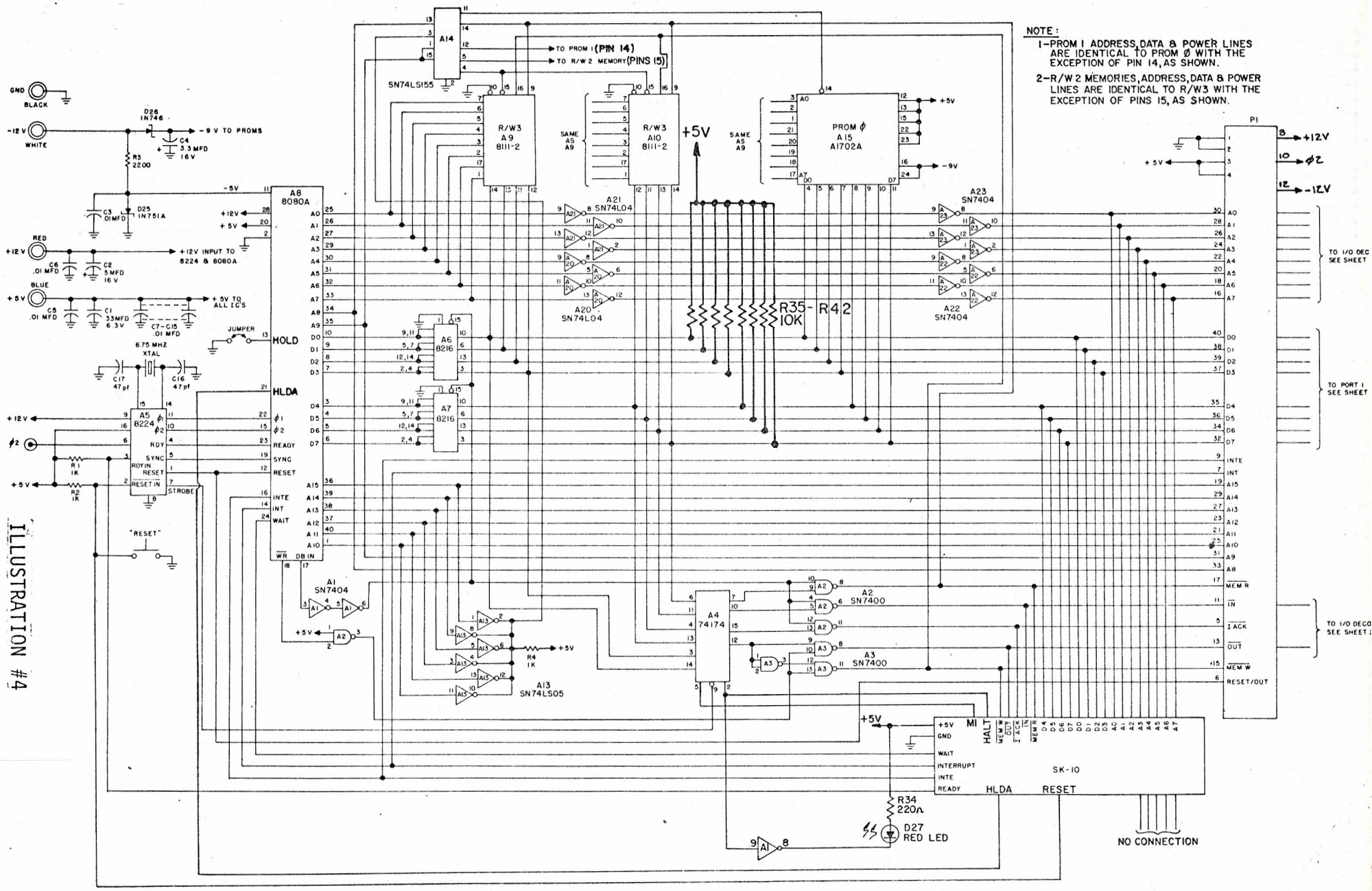


ILLUSTRATION #4

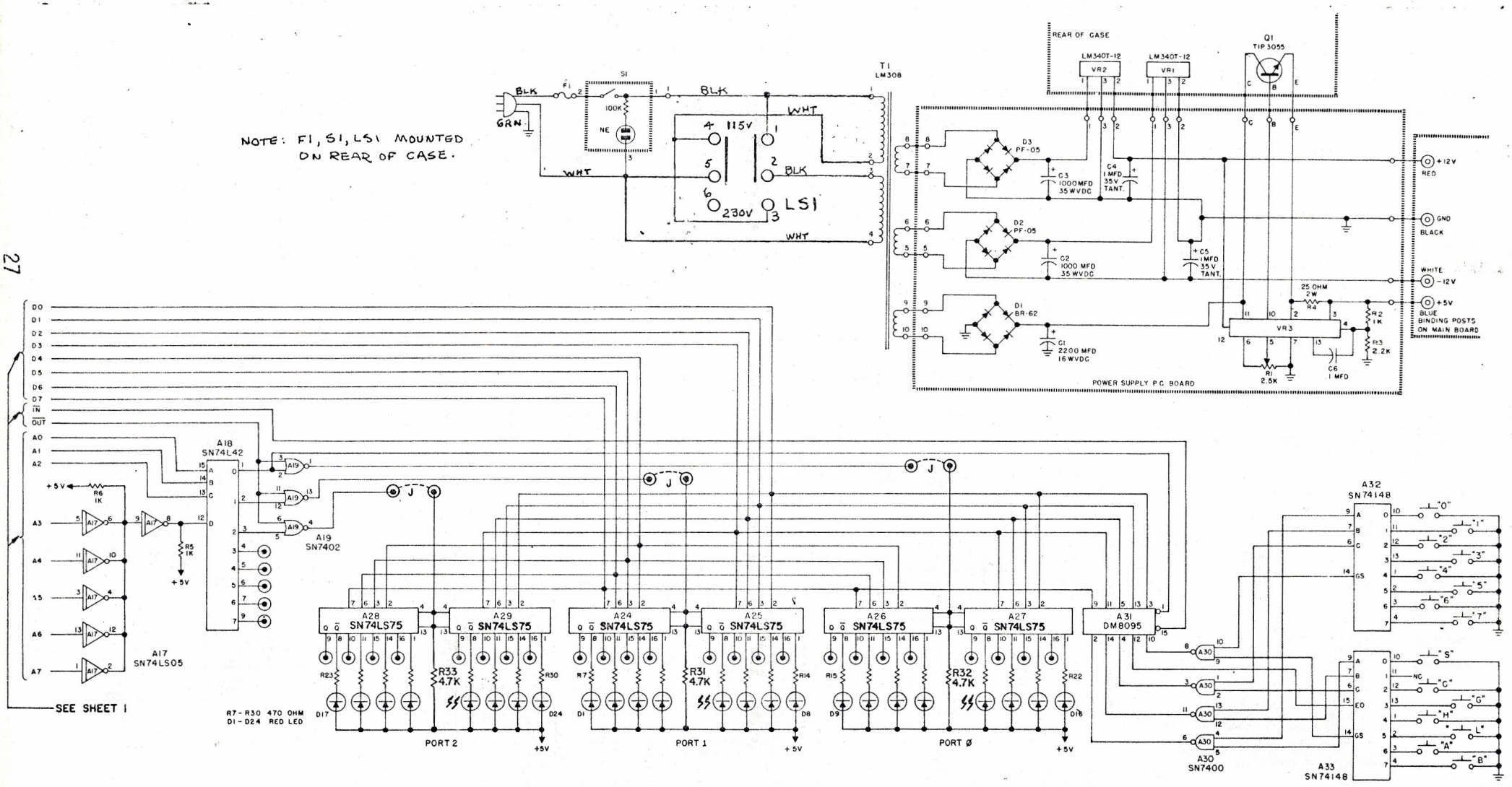


ILLUSTRATION #5

VII. Operation-How to Use the Mini-Micro

The Keyboard Executive software is the 'heart' of the system. It allows you to examine data or program steps and it allows you to change data or program steps stored in the R/W portion of the memory. We can also specify any address and start the program there. The keyswitches are labeled 0-7 for octal data, H for HI Address, L for LO Address, G for Go and S for See and Store. Three keys are not used by the KEX, A, B and C. The Reset key, R, will always reset the computer and restart the KEX if its PROM is in place. All manual data entry is through the keyboard in the basic Mini-Micro system and there are no binary toggle switches to worry about.

Whenever you want to start the system, depress R. This will reset the KEX and it will always output the first address in the R/W block of memory in section 3. This is HI=003 and LO=000. If you will only be using one block of R/W memory to get started, it MUST be in block 3. The KEX will not function without R/W memory in section 3.

To enter data, whether it will be used for new data or addresses, simply depress the numbered keys as you would on a calculator. Data will be entered into the three least significant (right-most) LEDs and it will shift to the left as more data is entered. If a mistake is made, simply reenter the data. Mistakes are shifted out the left side and lost. The Data Register LEDs will display the data just entered from the keyboard and this may be used as HI Address data by depressing H, or it may be used as LO Address data by depressing L. These keys will transfer the data to the proper LED display register and it will be used by the 8080A to address a new memory location.

Whenever a new H or L is specified by actuating one of these two keys, the KEX will always output the contents of the specified location on the Data Register LEDs. To examine the next location, depress the S key for its See function. By depressing S again and again, we can examine data in sequential memory locations. It should be noted that this See function follows increasing memory locations, <u>not</u> the sequential <u>flow</u> of a program.

To change the data in a R/W memory location, simply load the address using the data input key and the H and L keys. The old data presently in the location will immediately appear on the Data Register LEDs. Enter the new data into the Data register using the numeric keys and then enter it into the R/W location by depressing the S key for the Store function. After S is actuated, the new data is stored and the address is automatically incremented by one to go to the next location. The data from the next location is now displayed on the Data Register LEDs. The S key has two functions, both See and Store. How can we tell the difference? If the data has changed we will store it and see the next location. If the data hasn't changed, we will store it back where it came from and then see the next location. When we store old data back to the location from which we got it,we can't really see any change, but this is exactly what the KEX does. It inputs data from the specified location, allows us to make changes and then puts it back. If no changes are made, the old data is restored to its memory location.

Once a program is entered into the computer through the keyboard, we can start it by loading our starting address and actuating the G or Go key. This will transfer control from the KEX software to the software that we want to try. Starting addresses are loaded in the same way that we use them to examine and alter locations. Starting addresses don't have to be in R/W memory, but can just as easily be in PROM.

If your program starts at the first location in R/W memory, 003 000, you can simply depress R followed by G. We can do this because KEX always resets the address back to this first R/W location.

Keys labeled A, B and C are not used by KEX. It should be remembered that the three LED output ports and the keyboard input port are not hardwired for KEX alone. They are available for you to use in your programs. All fifteen keys may be used in any way you like, using software.

Keyboard Executive Software

The Keyboard Executive software is in a single 1702A type PROM which goes in PROM socket 0. This contains all the necessary software to operate the keyboard and the LED displays. This is our software controlled 'front panel',since the keys and LEDs perform functions determined by the KEX software.

How KEX Operates

Whenever the R key is depressed, the 8080A CPU chip will start to execute the program that starts at location 0. Looking at the software listing for KEX you will see that immediately after starting at location 0, the software instructions cause the computer to jump to location HI=000, LO=070 (HI=000 throughout KEX) where we START the program by pointing to the first R/W memory address in our minimum system, 003 000. The address and the data in that location are displayed on the three output ports. This is done between POINTA and POINTC. The software between POINTC and POINTD will do the necessary tasks to input new data from the keyboard and shift the data onto the LEDs. The shifting is done inside the 8080A with software instructions. Doing this in hardware would take many more chips, but it takes relatively few software steps. The software routines at POINTD, POINTE, POINTF and POINTG make up what is called a command decoder. The software decodes the key codes into real actions. Depressing H or L causes the data temporarily stored in the 8080A as numeric key inputs to be output to either the HI or LO set of LEDs. The S key code causes the current or new data to be put back into the memory location that we are looking at. Depressing G causes the computer to use the HI and LO address as the starting point for a new program.

The TIMOUT and KBRD software subroutines have specific tasks. TIMOUT will count its way through various loops for about 10 milliseconds, while the KBRD subroutine will input code from the keyboard. The KBRD subroutine has some unique features which illustrate an interesting hardware-software tradeoff. The keyswitches used in the Mini-Micro are not bounce free, so that when contacts are opened or closed, they can often re-make or re-break the contacts. This can be confusing to the computer since it can't distinguish between a real switch closure and a bounce. We don't want the computer to sense each bounce as a key closure so we would like some way to filter them out. Additional circuitry including latches, clocks and monostables could do this for us, but it complicates the system. We can also do the debouncing in software. The KBRD subroutine will recognize any key closure, but it will only input the key codes after being sure that the key is closed and not bouncing. It does this by waiting after sensing closure and then rechecking the switch to be sure it is still closed. It also checks when we release a key to be sure that it has stopped bouncing before it tries to sense another key being depressed by the user. We have traded some additional software steps for a great deal of hardware. Since we had plenty of PROM left, it was easy to include.

Since the TIMOUT and KBRD software segments have been set up as subroutines, you can use them in your software and in the experiments. Each of these subroutines may be started with a CALL instruction, 315.

The TIMOUT subroutine does not affect any of the registers or flags and it only serves to delay the software flow by 10 msec. The KBRD subroutine will return with the key code for the depressed key in the A register in the 8080A CPU chip. Flags and, of course, the A register have been used and modified.

An important distinction between the 8008 and the 8080 processors is in the use of subroutines. In the 8008, return pointer addresses were stored in the 8008 chip itself. In the 8080, these return pointer addresses are stored in a portion of the R/W memory. This is called a "stack" area, Whenever a subroutine is used we want to do the subroutine's task and then return back to the normal program flow. These return addresses are very important to the computer since they provide the only link between the subroutine and the main program. If we are to store them in a portion of R/W memory, the computer must know where this storage area is if it is to be able to use the addresses properly. In the KEX software this is set to be the top of the R/W memory with instructions at locations 070, 071 and 072. The LXISP instruction loads an internal 8080 stack Pointer Register to HI=004, LO=000. Since the Stack Pointer Register is decremented to point to a new location before anything is stored, the first stack location will be HI=003, LO=377. Check your sixteen bit binary numbers if this looks a little confusing.

You can use the stack as set up by the KEX (generally a good idea) or you can put your own stack anywhere you want, just by using the LXISP instruction. Remember to avoid the stack area when writing your programs. Remember, too, that you can't put the stack in an area of non-existent memory or in PROM.

You will use the stack area and you'll see how it can also be used to temporarily store data. This will be covered in the software modules. Let's see how the TIMOUT and KBRD subroutines can be used in our own software. We will use the software stack already set up in KEX.

Let's input a keyboard character, add a constant to it and display the result. We would first CALL the KBRD subroutine to input a binary key code, then add the constant and display the result.

The following software will do this:

```
HI   LO   INSTR     MNEMONIC
003  000  315       CALL          /Input keyboard character
003  001  315       KBRD          /Subroutine's LO address
003  002  000        0            /Subroutine's HI address
003  003  306       ADI           /Add the following DATA to
003  004  ???       DATA          /the contents of register A
003  005  323       OUT           /Output data from register A to
003  006  000       000           /device 000 (LEDs)
003  007  303       JMP           /Jump back to program at
003  010  000       000           /LO address =000
003  011  003       003           /HI address =003
```

You can enter this with KEX, just restart, specify HI=003 and LO=000 and start entering data. Enter 000 at location 003 004 so we'll first add zero to the codes. This will let us check what values are assigned to each key. Write down the codes. Go back and restart KEX and change the value in 003 004 to, say, 005. This will add 5 to each code. Restart your software and see if this is the case. Congratulations, you have just done your first software experiment! The instructions at 003 003 and 003 004 could be changed to do other things to the data. Can you suggest one?

The 10 msec delay routine, TIMOUT, can be useful when we want a software delay that is in multiples of 10 msec. The following software routine will delay an output of all 1's on Output Port 0 by about 2.5 seconds after the program is started. Try it. Can you see how the time delay might be shortened? Can you see any use for programs like this?

Assume HI=003 throughout this program:

```
LO   INSTR    MNEMONIC

000  006      MVIB          /Load register B with the following data
001  370      370           /Data: time constant
002  315      CALL          /Call TIMOUT subroutine at
003  277      277           /LO address =277
004  000      000           /HI address =000
005  005      DECB          /Decrement B by 1
006  302      JNZ           /Jump if result is not zero to
007  002      002           /LO address =002
010  003      003           /HI address =003
011  076      MVIA          /Load register A with the following data
012  377      377           /Data; all 1's
013  323      OUT           /Output to device,
014  000      000           /device 000 (LEDs)
015  166      HLT           /Stop once you reach here
```

The keyboard input subroutine, KBRD, is called at address 000 315 and the time delay subroutine, TIMOUT, is called at address 000 277.

The 8080A Microprocessor

The 8080A type microprocessor chip is an eight bit paralled central processing unit (CPU) in which data is operated upon and decisions made. Unlike the earlier 8008 and 8008-1, the 8080A is a more powerful, easy to use device. The 8008 was an 18 pin device and many things were multiplexed on the same bus. The 8080A is a 40 pin package which offers many advantages over the earlier devices:

- simplified bus, separate address (16 bits) and data (8 bits) buses
- three state and TTL compatible buses
- simplified control
- improved interrupt and stack
- more instructions

While the power and clock requirements for the 8080A are a bit more complex than for the 8008, they are easily met.

How the Mini-Micro Works

The Mini-Micro uses the same basic computer functions found in most other computers, large or small. These are:

- Central processing unit (CPU)
- Memory (R/W and PROM)
- Control Logic
- Input/Output Control
- Clock and power supplies

The 8080A has 24 data output lines, sixteen of which are used for address information and eight of which are a bidirectional data bus taking data to and from the CPU. The data flow on the data bus is controlled by the DBIN or Data Bus IN signal output by the 8080A chip on pin 17. Two bus buffers, Intel type 8216, are used to boost or buffer the data bus outputs and to protect the 8080A's imputs. The DBIN signal switches the 8216 buffer chips for either input or output of data on the bus.

The system's operation is controlled by signals output by the 8080A at various times as synchronized by the clock frequency. An Intel 8224 clock chip with a 6.75 MH_Z crystal is used to provide the 750 KH_Z MOS clock levels to the 8080A. These clocks are slightly out of phase and are nonoverlapping. While the 8080A chip can operate at frequencies up to 2 MH_Z, the Mini-Micro's clock has been set to 750 KH_Z so that it will work with the relatively slow 1702A type PROMs. You can increase the speed of the Mini-Micro by using a higher frequency crystal. The 8224 chip divides the crystal's frequency by nine, so an 18 MH_Z crystal will give the 2 MH_Z output needed for the highest operating speed.

The clock chip also synchronizes the Ready input with the clock so that system can slow down for slow memories and I/O devices. The Reset input from the R key is also input to the 8224 chip where it, too, is synchronized to the clock, and output to reset the 8080A.*

The 8080A's data bus will also contain some STATUS information which is used by the Control Logic section to synchronize its control operations. The STATUS information is output and is available when the SYNC signal is output from the 8080A. The 8224 clock chip gates the SYNC pulse from the 8080A with the main system clock to provide a very short STSTB signal or Status Strobe which 'catches' the status information in the SN74174 latch. The status information indicated data output, data input, halt condition, memory read, memory write and a special condition which signals the start of the next instruction, M1. Four of these status signals are gated with other system signals to provide the $\overline{IN}$, $\overline{OUT}$, $\overline{MW}$ and $\overline{MR}$ signals used throughout the Mini-Micro. These signals are used as indicated on the next page.

* For more information about these signals and chips, see Intel's 8080 Microcomputer System User's Manual, Sept. 1975 and Bugbooks V and VI , for further information.

$\overline{IN}$ and $\overline{OUT}$ - used to synchronize data flow to ($\overline{IN}$) and from ($\overline{OUT}$) the 8080A CPU. They are used with external devices for data transfer.

$\overline{MR}$ and $\overline{MW}$ - used to indicate to the memory that the computer is executing a Memory Read or a Memory Write.

$\overline{INTA}$ - indicates that the computer has acknowledged an interrupt.

HALT and M1 - latched and provided for the user. These are not used in the Mini-Micro, but are described in the experiment modules and are available for your use.

When the 8080A addresses memory, one and only one address must be specified on the 16 bit address lines. Since the 1702A and the 8111-2 memories only have eight input address lines to address their 256 locations, the remaining eight address lines must be used to select one and only one of the memory blocks. We can select from two blocks of PROM, two blocks of R/W or possibly no blocks on the Mini-Micro if we have expanded the memory off the card.

Address lines A0 through A7 are applied directly to the memory chips on the Mini-Micro card. Address lines A10 through A15 are gated in a six input NOR gate made from an SN74LS05 open collector inverter, IC13. When this gate's output is a logic 1, it indicates that we are selecting one memory location within the first 1024 locations. Address lines A10 - A15 are equal to logic 0. This would be one of the locations in either R/W or PROM, since these are located within the first 1024 locations. If the NOR gate indicates a logic 0, at least one of the address inputs, A10 -A15, must be at a logic 1, indicating that we are now addressing memory outside the blocks on the Mini-Micro. Address bits A8 and A9 and the memory read signal $\overline{MR}$ are gated together in an SN74LS155 decoder to select the proper block of the four possible on the Mini-Micro card. The 8111-2 memories input the memory read and memory write signals to control the flow of data from and to the CPU. The 1702A PROM has only a chip select input, so the memory read synchronizing signal is used in the SN74LS155 to gate data from the 1702A onto the bus at the correct time. Table 1 shows the memory selection.

Table 1. MEMORY SELECTION

NOR Gate Output	A9	A8	$\overline{MR}$	Memory Selected
0	X	X	X	NONE
1	0	0	0	PROM 0
1	0	1	0	PROM 1
1	0	0	1	NONE
1	0	1	1	NONE
1	1	0	X	R/W 2 *
1	1	1	X	R/W 3 *

* MR and MW applied independently to the 8111-2 chips
X = Don't care condition, logic 0 or logic 1

Data flows to and from the memory on the bidirectional data bus and the sixteen bit address bus specifies each location. This address bus is also used to help control the flow of data to and from external devices. The eight least significant or LO address bits can specify one of 256 possible peripheral devices. The address bits are decoded in the Mini-Micro to select one of four possible on-board devices. These are the three groups of LEDs and the keyboard. Address bits A3 - A7 are all ORed together in IC17, an OR gate made from a series of open-collector inverters in an SN74LS05 chip. If the eight bit LO address outputs a value greater than seven, the OR gate's output becomes a logic 1. Address bits A0 - A2 are used in IC 18, an SN74L42 decoder chip to provide a one-out-of-eight code for devices 0 to 7. The OR gate's output is used to enable the decoder for device coded 0 - 7, but to disable it for other codes. The decoding scheme is shown in Table 2.

Table 2. On-Board I/Q DEVICE DECODER

OR Gate Output	A2	A1	A0	Mini-Micro Device
1	X	X	X	NONE
0	0	0	0	LED Port 0, Keyboard
0	0	0	1	LED Port 1
0	0	1	0	LED Port 2
0	0	1	1	Available for user
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	

X = Don't care condition, logic 1 or logic 0.

You will notice that device code 0 selects both the LED Port 0 and Input Port 0, the keyboard. How can the computer output and input data at the same time. It can't, and some means must be used to distinguish between them. The Control Logic section outputs two

control signals, $\overline{IN}$ and $\overline{OUT}$ which indicate whether data will be input to the CPU or output to an external device. Both signals are exclusive, never taking place at the same time. The pulses are generated by the 8080A and the Control Logic section under control of our software. Only when we execute an I/O type instruction will either of these signals be generated. The device codes for theSN74LS75latches are gated with $\overline{OUT}$ in IC19, a NOR gate package, and the $\overline{IN}$ is gated with the keyboard device doce in the DM8095 buffer chip associated with the keyboard, IC31. Data is input or output only when we have a valid device code and either $\overline{IN}$ or $\overline{OUT}$.

A software-hardware user's group has been formed for the Mini-Micro. People interested should contact:

Digital Directions, Editor
E & L INSTRUMENTS, INC.
61 First St.
Derby, CT 06418

VIII. KEX PROM PROGRAM LISTING (OCTAL)

ADDRESS HI	ADDRESS LOW	DATA $B_7 \ldots B_0$		
				*000 000
000	000	303		JMP
000	001	070		START
000	002	000		0
				/ JUMP UP TO R/W MEMORY TO BE USED BY
				/ RESTARTS & VECTORED INTERRUPTS
				*000 010
000	010	303		JMP
000	011	010		010
000	012	003		003
				*000 020
000	020	303		JMP
000	021	020		020
000	022	003		003
				*000 030
000	030	303		JMP
000	031	030		030
000	032	003		003
				*000 040
000	040	303		JMP
000	041	040		040
000	042	003		003
				*000 050
000	050	303		JMP
000	051	050		050
000	052	003		003
				*000 060
000	060	303		JMP
000	061	060		060
000	062	003		003
				/ BEGINNING OF MAIN PROGRAM
				*000 070
000	070	061	START,	LXISP /SET STACK POINTER TO TOP OF R/W MEM.
000	071	000		000
000	072	004		004
000	073	041		LXIH /INITIAL VALUE OF H & L
000	074	000		000
000	075	003		003
000	076	116	POINTA,	MOVCM /LOAD MEM DATA INTO TEMP DATA BUFFER
000	077	174		MOVAH /OUTPUT HI TO LED'S
000	100	323		OUT
000	101	001		001
000	102	175		MOVAL /OUTPUT LOW TO LED'S

VIII. KEX PROM PROGRAM LISTING (OCTAL)

ADDRESS HI	ADDRESS LOW	DATA $B_7...B_0$		
000	103	323		OUT
000	104	000		000
000	105	171	POINTB,	MOVAC / OUTPUT TEMP. DATA BUFFER DATA TO LED'S
000	106	323		OUT
000	107	002		002
000	110	315	POINTC,	CALL / WAIT & INPUT NEXT KEY CLOSURE
000	111	315		KBRD
000	112	000		0
000	113	376		CPI
000	114	010		010
000	115	322		JNC / JUMP IF KEY WAS < 010
000	116	134		POINTD / (0-7 , OCTAL DIGIT)
000	117	000		0
000	120	107		MOVBA / SAVE KEY CODE
000	121	171		MOVAC / GET OLD VALUE
000	122	027		RAL / ROTATE 3 TIMES
000	123	027		RAL
000	124	027		RAL
000	125	346		ANI / MAK OUT LEAST SIG. OCTAL DIGIT
000	126	370		370
000	127	260		ORAB / OR IN NEW OCTAL DIGIT
000	130	117		MOVCA / PUT NEW DATA BACK INTO BUFFER
000	131	303		JMP
000	132	105		POINTB
000	133	000		0
000	134	376	POINTD,	CPI
000	135	011		011 / "L" KEY
000	136	302		JNZ / JUMP IF NOT AN "L"
000	137	145		POINTE
000	140	000		0
000	141	151		MOVLC / PUT BUFFER DATA IN L
000	142	303		JMP
000	143	076		POINTA
000	144	000		0
000	145	376	POINTE,	CPI
000	146	010		010 / "H" KEY
000	147	302		JNZ / JUMP IF NOT AN "H"
000	150	156		POINTF
000	151	000		0
000	152	141		MOVHC / PUT BUFFER DATA IN H
000	153	303		JMP
000	154	076		POINTA
000	155	000		0
000	156	376	POINTF,	CPI
000	157	013		013 / "S" KEY
000	160	302		JNZ / JUMP IF NOT "S"
000	161	170		POINTG
000	162	000		0
000	163	161		MOVMC / PUT TEMP. DATA INTO MEMORY
000	164	043		INXH / INCERMENT H & L
000	165	303		JMP
000	166	076		POINTA
000	167	000		0
000	170	376	POINTG,	CPI

VIII. KEX PROM PROGRAM LISTING (OCTAL)

```
ADDRESS      DATA
HI  LOW      B7...B0

000 171        012          012      / "G" KEY
000 172        302          JNZ      / JUMP IF NOT "G"
000 173        110          POINTC
000 174        000          0
000 175        351          PCHL     / GO EXECUTE PGM POINTED TO BY H & L


                            / THIS 10 MSEC DELAY DISTURBS NO REGISTERS OR FLAG

                            *000 277
000 277        365  TIMEOUT,PUSHPSW / SAVE REGISTERS
000 300        325          PUSHD
000 301        021          LXID     / LOAD D & E WITH VALUE TO BE DECREMENTED
000 302        046          046
000 303        001          001
000 304        033  MORE,   DCXD     / JUMP IN THIS LOOP UNTIL
000 305        172          MOVAD    /    D & E ARE BOTH ZERO
000 306        263          ORAE
000 307        302          JNZ
000 310        304          MORE
000 311        000          0
000 312        321          POPD
000 313        361          POPPSW   / RESTORE REGISTERS
000 314        311          RET


                            / THE KBRD ROUTINE DEBOUNCES KEY CLOSURES
                            /     AND TRANSLATES KEY CODES

                            / FLAGS AND REG A ARE CHANGED
                            / A0-A3= CODE  ; A4-A7= 0000

000 315        333  KBRD,    IN       / INPUT FROM KEYBOARD ENCODERS
000 316        000          000
000 317        267          ORAA     / SET FLAGS
000 320        372          JM       / JUMP BACK IF LAST KEY NOT RELEASED
000 321        315          KBRD
000 322        000          0
000 323        315          CALL     / WAIT 10 MSEC
000 324        277          TIMOUT
000 325        000          0
000 326        333  FLAGCK, IN
000 327        000          000
000 330        267          ORAA
000 331        362          JP       / JUMP BACK TO WAIT FOR A NEW
000 332        326          FLAGCK   /   KEY TO BE PRESSED
000 333        000          0
000 334        315          CALL     / WAIT 10 MSEC FOR BOUNCING
000 335        277          TIMOUT
000 336        000          0
000 337        333          IN
000 340        000          000
000 341        267          ORAA
000 342        362          JP       / JUMP BACK IF NEW KEY NOT STILL
```

VIII. KEX PROM PROGRAM LISTING (OCTAL)

ADDRESS HI	ADDRESS LOW	DATA $B_7 \ldots B_0$			
000	343	326		FLAGCK	/ PRESSED (FALSE ALARM)
000	344	000		0	
000	345	346		ANI	/ MASK OUT ALL BUT KEY CODE
000	346	017		017	
000	347	345		PUSHH	/ SAVE H&L
000	350	046		MVIH	/ ZERO H REG
000	351	000		000	
000	352	306		ADI	/ADD THE ADDRESS OF THE BEGINNING OF
000	353	360		360	/ THE TABLE TO THE KEY CODE
000	354	157		MOVLA	/
000	355	176		MOVAM	/ FETCH NEW VALUE FROM TABLE
000	356	341		POPH	/ RESTORE H & L
000	357	311		RET	
					/ THIS TRANSLATION TABLE CONVERTS THE CODE
					/ GENERATED BY KEY CLOSURES TO THE CODE
					/ USED BY THE MAIN KEX PROGRAM
000	360	000	TABLE,	000	
000	361	001		001	
000	362	002		002	
000	363	003		003	
000	364	004		004	
000	365	005		005	
000	366	006		006	
000	367	007		007	
000	370	013		013	/ S
000	371	000		000	/ THIS CODE CAN'T BE GENERATED
000	372	017		017	/ C
000	373	012		012	/ G
000	374	010		010	/ H
000	375	011		011	/ L
000	376	015		015	/ A
000	377	016		016	/ B

IX. LOAD/DUMP PROM PROGRAM LISTING (OCTAL)

This is a listing of the Loader/Dump program when resident in the main board PROM (PROM "1").

```
                                / 7-13-76  MMD-1 M-I Routines
                                / THE FOLLOWING ROUTINES ARE USED WITH THE
                                / MMD-1 MEMORY-INTERFACE BOARD


                                / THE READ FROM CASSETTE ROUTINE, RCAS, READS
                                / DATA FROM THE CASSETTE AND STORES IT IN
                                / SUCESSIVE MEMORY LOCATIONS ON THE M-I
                                / BOARD, STARTING AT 030 000.  AS THE DATA IS INPUT
                                / IT IS DISPLAYED ON THE MMD-1'S LEDS.

                                001  000

001 000  041   RCAS,           LXIH    / INITIALIZE THE MEMORY POINTER
001 001  000                   000
001 002  030                   030
001 003  333                   IN      / CLEAR FLAGS IF NECESSARY
001 004  022                   022
001 005  315   NEXTIN,         CALL    / INPUT A BYTE OF DATA
001 006  103                   CASIN
001 007  003                   0
001 010  167                   MOVMA   / STORE THE DATA
001 011  323                   OUT     / OUTPUT DATA AND ADDRESS
001 012  002                   002
001 013  175                   MOVAL
001 014  323                   OUT
001 015  000                   000
001 016  174                   MOVAH
001 017  323                   OUT
001 020  001                   001
001 021  043                   INXH    / INCREMENT THE MEMORY POINTER
001 022  303                   JMP     / JUMP BACK FOR MORE DATA
001 023  005                   NEXTIN
001 024  001                   0


                                / THE WRITE ONTO CASSETTE ROUTINE, WCAS, IS USED
                                / TO STORE ON CASSETTE FROM 1 TO 8 256 BYTE BLOCKS
                                / OF MEMORY STARTING AT 030 000.  ONCE THE ROUTINE
                                / HAS BEEN STARTED, A KEY ON THE MMD-1 KEYBOARD IS
                                / PRESSED TO INDICATE HOW MANY 256 BYTE BLOCKS ARE
                                / TO BE TRANSFERED. (KEY "0" INDICATES 8 BLOCKS.)
                                / THEN AFTER A 5 SECOND DELAY THE DATA IS WRITTEN
                                / ONTO THE CASSETTE; AFTER ANOTHER 5 SECOND DELAY
                                / CONTROL IS RETURNED TO KEX.

001 025  041   WCAS,           LXIH    / INITIALIZE THE MEMORY POINTER
001 026  000                   000
001 027  030                   030
001 030  315   KEY,            CALL
```

IX. LOAD/DUMP PROM PROGRAM LISTING (OCTAL)

```
ØØ1 Ø31  315                    315     / KEX KEYBOARD INPUT ROUTINE
ØØ1 Ø32  ØØØ                    ØØØ
ØØ1 Ø33  376                    CPI     / CHECK FOR Ø-7
ØØ1 Ø34  Ø1Ø                    Ø1Ø
ØØ1 Ø35  322                    JNC     / IF NOT, JUMP BACK
ØØ1 Ø36  Ø3Ø                    KEY
ØØ1 Ø37  ØØ1                    Ø
ØØ1 Ø4Ø  267                    ORAA    / S SET FLAGS
ØØ1 Ø41  3Ø2                    JNZ
ØØ1 Ø42  Ø46                    NOTØ
ØØ1 Ø43  ØØ1                    Ø
ØØ1 Ø44  3Ø6                    ADI     / ADD 8 IF ZERO KEY
ØØ1 Ø45  Ø1Ø                    Ø1Ø
ØØ1 Ø46  2Ø4    NOTØ,           ADDH    / COMPUTE STOPPING ADDRESS
ØØ1 Ø47  127                    MOVDA   / SAVE IT IN REG D
ØØ1 Ø5Ø  315                    CALL    / DELAY FOR 5 SECONDS
ØØ1 Ø51  13Ø                    FIVSEC
ØØ1 Ø52  ØØ1                    Ø
ØØ1 Ø53  176    MORE,           MOVAM   / GET DATA FROM MEMORY
ØØ1 Ø54  315                    CALL    / OUTPUT TO CASSETTE
ØØ1 Ø55  114                    CASOUT
ØØ1 Ø56  ØØ1                    Ø
ØØ1 Ø57  323                    OUT     / DISPLAY DATA AND ADRESS
ØØ1 Ø6Ø  ØØ2                    ØØ2
ØØ1 Ø61  175                    MOVAL
ØØ1 Ø62  323                    OUT
ØØ1 Ø63  ØØØ                    ØØØ
ØØ1 Ø64  174                    MOVAH
ØØ1 Ø65  323                    OUT
ØØ1 Ø66  ØØ1                    ØØ1
ØØ1 Ø67  Ø43                    INXH    / INCREMENT THE MEMORY POINTER
ØØ1 Ø7Ø  174                    MOVAH
ØØ1 Ø71  272                    CMPD    / CHECK FOR END OF LOOP
ØØ1 Ø72  3Ø2                    JNZ     / JUMP BACK IF MORE DATA TO BE OUTPUT
ØØ1 Ø73  Ø53                    MORE
ØØ1 Ø74  ØØ1                    Ø
ØØ1 Ø75  315                    CALL    / DELAY 5 SECONDS
ØØ1 Ø76  13Ø                    FIVSEC
ØØ1 Ø77  ØØ1                    Ø
ØØ1 1ØØ  3Ø3                    JMP     /. RETURN TO KEX
ØØ1 1Ø1  Ø7Ø                    Ø7Ø
ØØ1 1Ø2  ØØØ                    ØØØ


                                / THE CASSETTE INPUT SUBROUTINE, CASIN, WAITS
                                / FOR DATA TO BE RECEIVED BY THE CASSETTE
                                / UART, AND INPUTS THE DATA.

ØØ1 1Ø3  333    CASIN,          IN      / INPUT STATUS BITS
ØØ1 1Ø4  Ø23                    Ø23
ØØ1 1Ø5  Ø37                    RAR
ØØ1 1Ø6  322                    JNC     / JUMP BACK IF NO DATA AVAILABLE YET
ØØ1 1Ø7  1Ø3                    CASIN
```

IX. LOAD/DUMP PROM PROGRAM LISTING (OCTAL)

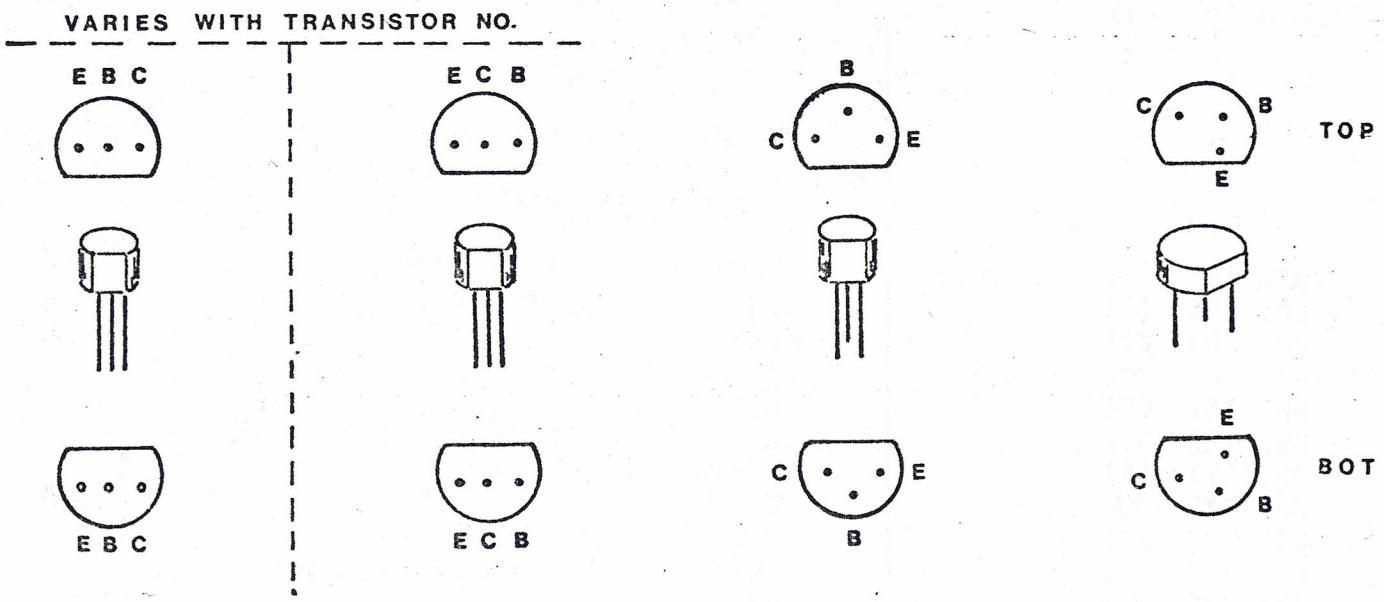
```
001 110  001                    0
001 111  333                    IN      / INPUT DATA
001 112  022                    022
001 113  311                    RET


                                / THE CASSETTE OUTPUT SUBROUTINE, CASOUT, WAITS
                                / IF THE TRANSMITTER HOLDING REGISTER IS FULL,
                                / AND THEN OUTPUTS THE DATA

001 114  365  CASOUT,           PUSHPSW / SAVE DATA
001 115  333                    IN      / INPUT STATUS BITS
001 116  023                    023
001 117  346                    ANI
001 120  004                    004
001 121  312                    JZ      / JUMP IF TRANSMISSION REG. NOT EMPTY
001 122  115                    CASOUT+1
001 123  001                    0
001 124  361                    POPPSW  / RESTORE DATA
001 125  323                    OUT     / OUTPUT DATA
001 126  022                    022
001 127  311                    RET


                                / THE FIVE SECOND DELAY SUBROUTINE, FIVSEC, DELAYS
                                / FOR FIVE SECONDS BY REPEATEDLY CALLING THE
                                / 10 MSEC DELAY IN KEX.

001 130  365  FIVSEC,           PUSHPSW / SAVE REGISTERS
001 131  305                    PUSHB
001 132  001                    LXIB    / LOAD COUNT
001 133  364                    364
001 134  001                    001
001 135  315                    CALL    / KEX TIMOUT SUBROUTINE
001 136  277                    277
001 137  000                    000
001 140  013                    DCXB    / DECREMENT COUNT
001 141  170                    MOVAB
001 142  261                    ORAC
001 143  302                    JNZ     / JUMP IF COUNT IS NOT ZERO
001 144  135                    FIVSEC+5
001 145  001                    0
001 146  301                    POPB    / RESTORE REGISTERS
001 147  361                    POPPSW
001 150  311                    RET


                                / THE TELETYPE INPUT SUBROUTINE, TTYIN, WAITS FOR
                                / A CHARACTER TO BE RECEIVED BY THE TTY UART,
                                / INPUTS THE CHARACTER, MASKS OUT THE PARITY BIT,
                                / AND THEN ECHOS IT.
```

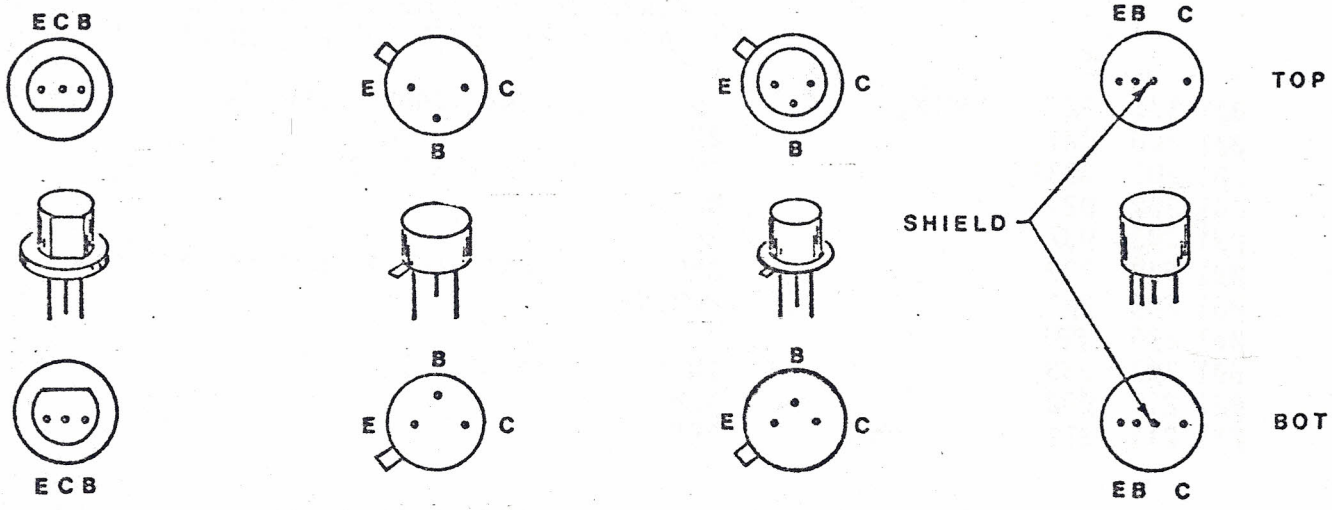
IX. LOAD/DUMP PROM PROGRAM LISTING (OCTAL)

```
001 151  333   TTYIN,          IN      / INPUT STATUS BITS
001 152  021                   021
001 153  037                   RAR
001 154  322                   JNC     / JUMP BACK UNTIL A CHARACTER IS RECEIVED
001 155  151                   TTYIN
001 156  001                   0
001 157  333                   IN      / INPUT THE CHARACTER
001 160  020                   020
001 161  346                   ANI     / MASK OUT THE PARITY BIT
001 162  177                   177


                               / THE TELETYPE OUTPUT SUBROUTINE, TTYOUT, WAITS
                               / IF THE TRANSMISSION HOLDING REGISTER IS NOT
                               / EMPTY, AND OUTPUTS THE CHARACTER.

001 163  365   TTYOUT,         PUSHPSW / SAVE THE CHARACTER
001 164  333                   IN      / INPUT STATUS BITS
001 165  021                   021
001 166  346                   ANI
001 167  004                   004
001 170  312                   JZ      / JUMP IF TRANSMITTER REG. NOT EMPTY
001 171  164                   TTYOUT+1
001 172  001                   0
001 173  361                   POPPSW  / RESTORE THE CHARACTER
001 174  323                   OUT     / OUTPUT THE CHARACTER
001 175  020                   020
001 176  311                   RET


                               / THE PAPER TAPE READER INPUT SUBROUTINE, RDRIN,
                               / TURNS ON THE READER RELAY CIRCUIT, WAITS FOR
                               / DATA TO BE RECEIVED, AND INPUTS IT.

001 177  323   RDRIN,          OUT     / TURN READER RELAY ON
001 200  021                   021
001 201  333                   IN      / INPUT STATUS BITS
001 202  021                   021
001 203  037                   RAR
001 204  322                   JNC     / JUMP BACK IF NO DATA AVAILABLE
001 205  201                   RDRIN+2
001 206  001                   0
001 207  333                   IN      / INPUT DATA
001 210  020                   020
001 211  311                   RET
```

```
RCAS   = 001 000  NEXTIN = 001 005  WCAS   = 001 025  KEY    = 001 030
NOT0   = 001 046  MORE   = 001 053  CASIN  = 001 103  CASOUT = 001 114
FIVSEC = 001 130  TTYIN  = 001 151  TTYOUT = 001 163  RDRIN  = 001 177

ERRORS DETECTED = 000
```

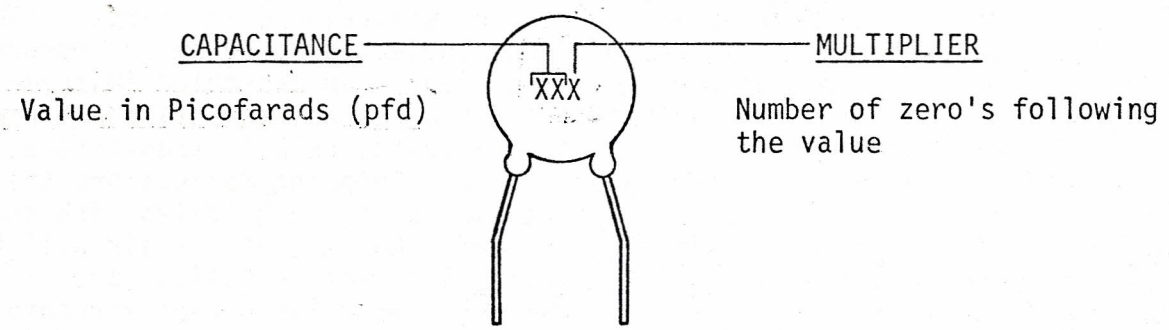
X. A.....TRANSISTOR ORIENTATION





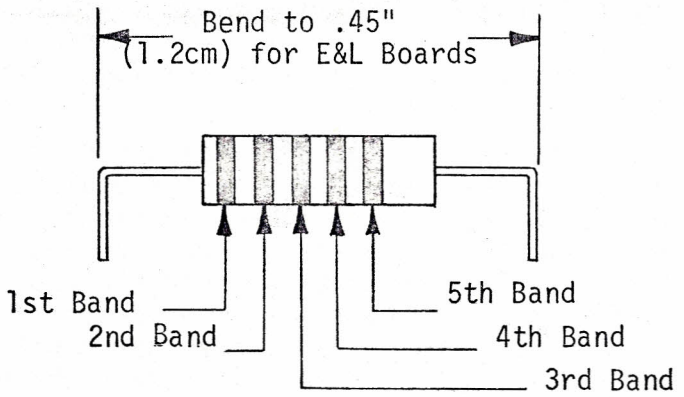
X.

B. General Ceramic Capacitor Identification



EXAMPLES:
103 = 10,000 pfd or .01 mfd
302 = 3,000 pfd or .003 mfd
676 = 67,000,000 pfd or 67 mfd

C. Resistor Color Code Chart



COLOR	BANDS				
	1st	2nd	3rd	4th	5th
Black	0	0	x1.0	-	
Brown	1	1	x10	-	
Red	2	2	x100	-	
Orange	3	3	x1000	-	
Yellow	4	4	x10000	-	
Green	5	5	x100,000	-	
Blue	6	6	x1000,000	-	RC=MIL-R-39008
Purple	7	7	-	-	
Grey	8	8	-	-	
White	9	9	-	-	
Gold	-	-	÷10	±5%	
Silver	-	-	÷100	±10%	
------	-	-	-	±20%	RC=MIL-R-11

XI. WARRANTY INFORMATION

1. ASSEMBLED INSTRUMENTS

E&L Instruments agrees to repair or replace, at no charge, any defects in assembled instruments for a period of one (1) year from date of purchase by the end user, or eighteen (18) months after purchase by an E&L Dealer (whichever comes first). The warranty is void if the returned equipment has been subjected to abuse or improper operation. Any assembly by the end user or Dealer to repair an assembled instrument during the warranty period voids the warranty. E & L makes no warranty concerning components not of E & L's manufacture (integrated circuits, relays, transistors, etc.) which carry the original warranty of the manufacturer. Shipping damages are the responsibility of the Dealer or end user. Prompt claims should be filed with the appropriate carrier if damage in transit has occurred. No warranty repair will be done on merchandise not returned in compliance with E&L's return policy (see Return Policy section of this manual). Instruments returned for out-of-warranty service will be repaired and billed to the sender at a standard labor rate of $20.00 per hour plus parts, or the current prevailing rate. E&L will perform repairs on non-warranty repairs up to an owner's cost of $50.00 without prior authorization by the sender. If, in the opinion of E&L, the non-warranty repair will cost more than $50.00, an estimate of repair costs will be made. The estimate will be forwarded to the owner for approval. Repair work will begin upon receipt of the owner's signed approval of the repair estimate. All repair charges will be on a C.O.D. basis. Rated companies desiring credit terms on repair charges must accompany the returned merchandise and/or approved repair estimate with a purchase order covering all repair costs and return freight.

2. KIT (Unassembled) INSTRUMENTS

Terms and conditions of warranty on kit products are identical to those on assembled instruments except for the following changes:

E & L warrantees kit products for a period of 90 days from time of purchase by the end user of 180 days from the date of purchase by the Dealer, whichever comes first. WARNING: Use of corrosive core solders or fluxes completely voids any warranty on kit products. Any kit received for repair and found to have been assembled with corrosive solders or fluxes will be returned to sender unrepaired, postage collect. E & L cannot warranty the workmanship of the kit builder. All kits returned requiring repair for reasons of wiring mistakes or poor workmanship will be repaired according to the Repair Section of this manual. On any kit repair which, in E&L's opinion, will incur repair costs over $25.00, an estimate of repair costs will be made and forwarded to the sender. The kit owner must approve, sign and forward the estimate to E&L before work can be initiated. All returned kits must comply with E&L's Returned Goods Policy (see Return Policy section of this manual).

** THE LIFETIME GUARANTEE **

All of E&L's SK sockets now carry a lifetime guarantee. If a socket ever fails to meet your requirements, return it to E&L, postpaid, for a free replacement, no questions asked.

All terms and conditions are subject to change without notice.

XII. REPAIR AND SHIPPING

1. REPAIR

All repairs done at the factory and found due to defective components, will be done on a no-charge basis for a period of ninety (90) days after the original shipping date of the kit.

After expiration of warranty period (90 days), repairs due to defective components will be billed at materials cost plus a flat charge of $25.00 per kit.

All kits returned requiring repair for reasons of wiring errors or poor workmanship will be repaired at the standard labor rate of $20.00 an hour plus parts, or the current prevailing rate.

E & L Instruments will return unrepaired any kit assembled with corrosive solder or fluxes.

2. SHIPPING INFORMATION

If you should find it necessary to return your kit to the factory for repair, please pack carefully and ship prepaid to:

E & L INSTRUMENTS, INC.
61 First Street
Derby, Connecticut 06418
ATTENTION: KIT REPAIR DEPARTMENT

3. RETURN POLICY

All merchandise returned to E & L for repair or for any other reason must comply with the following procedure:

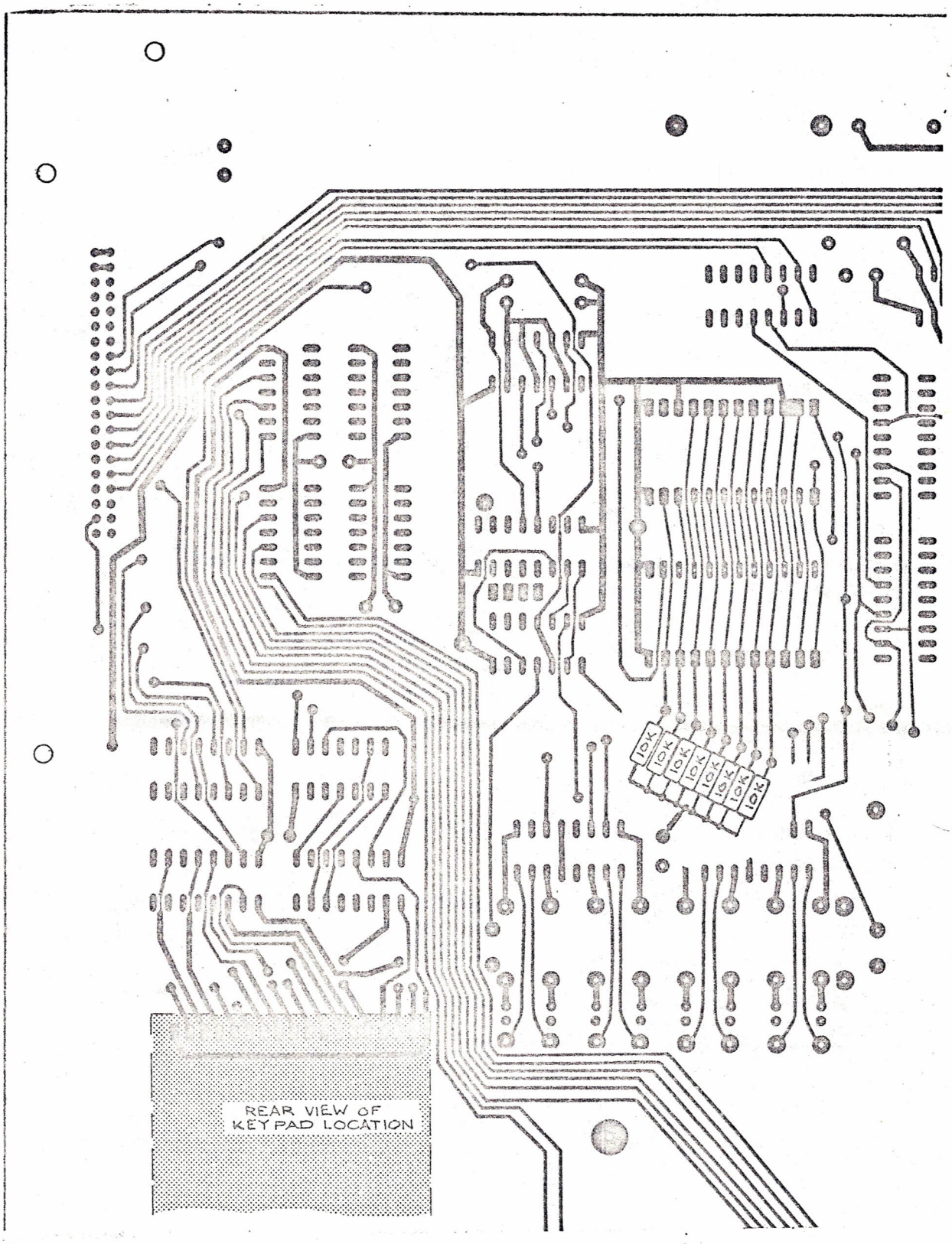
Prior to forwarding any returned merchandise to E & L, sender must request from E & L a Return Merchandise Authorization Number (RMA #). Sender should contact E & L by mail or telephone and request the RMA #.

A separate RMA # must be procured for each item being returned.

Upon request, E & L will forward the RMA Form to the sender. The form should be filled out completely, and the reason for returning the merchandise must be included on the RMA Form. A short description of any problems occuring with the material being returned for repair will shorten the repair time and is strongly suggested. The completed RMA Form must be in the carton with the returned merchandise, and the RMA Form Number should be prominently displayed on the outside of the shipping container.

Any material received at E & L without an RMA Number or without an RMA form enclosed will be returned to the sender freight collect.

ADDENDUM



Please take note that (8) 1/4 watt 10K 5% resistors must be installed as shown (factory installed in assembled units) on the rear of the board to the data lines DØ - D7, see schematic.

These resistors quarantee that the data bus will have a value of all ones when referencing non-existant memory or I/O.

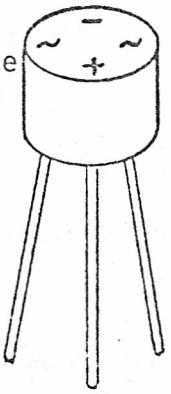
ENGINEERING NOTICE

Due to Manufacturers differences in packaging, you may find that the Bridge Rectifier called out in your manual is different than the actual part. The diagrams below will assist you in defining the leads.

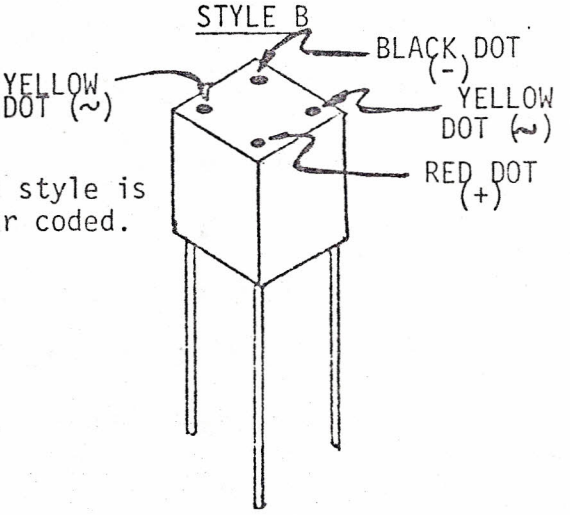
PF-05 Bridge Rectifier (1.5A 50PIV) E & L P/N: 502-0002

STYLE A

This style has each leg of the bridge stamped on the top of the case.



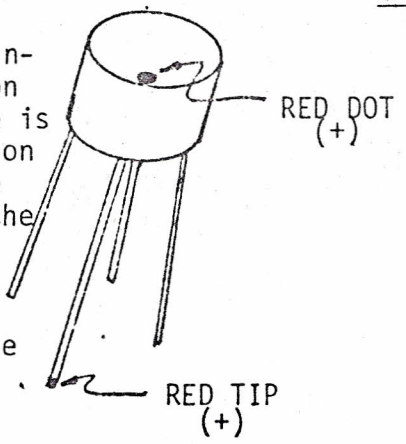
STYLE B

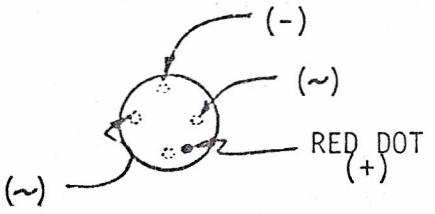


This style is color coded.

STYLE C

The only indication on this style is a red dot on top of the case and the plus leg has a red tip. The other three legs are assumed.





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61 FIRST ST DERBY, CT 06418

ENGINEERING NOTICE

Due to an internal change, by the manufacturers, to the 8224 Clock Generator Chip, the 47 pf capacitors (C 16 & C 17) are no longer necessary. We are not going to eliminate them from the manual at this time or change the pc board until we have made the proper tests and are certain that these caps will no longer be needed. All you have to do is ignore the references to these caps in your manual, we have eliminated from the bag of parts.

If you wish to go through your manual and note these changes now, they appear on pages 6, 18, and 19.

5/79
806-0034

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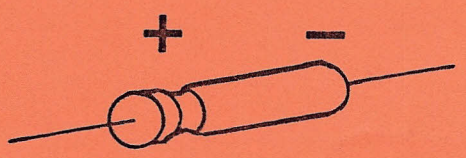
ENGINEERING NOTICE

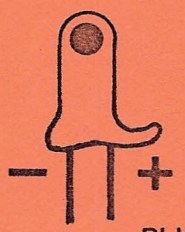
Due to manufacturers availability, the following capacitors may have been substituted in your kit:

Part Number:				
	524-0005	10 mfd	@	20 V
	524-0009	1 mfd	@	35 V
	524-0010	22 mfd	@	15 V
	524-0032	5 mfd	@	15 V

The substitution on the above parts is not a value substitution but a case style substitution.



OR



PLUS IS ALWAYS TO THE RIGHT OF THE DOT.

806-0026 (4-78)

ENGINEERING NOTICE

Due to manufacturers availability we are temporarily out of stock of SN74LS75's (P/N 503-0187). In order not to hold up the shipment of your unit we have elected to substitute SN7475's (P/N 503-0045). Please make the necessary changes in your manual.

806-0033
3/79

E&L Instruments, Incorporated
61 First Street, Derby, Connecticut 06418